Conflict Management

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Zusammenfassung

Menschen haben die beeindruckende Fähigkeit zu planen, sich Ziele zu setzen und entsprechend zu handeln. Dies ist aber nicht immer der Fall. Jeder kennt Situationen, in denen Impulse, wie zum Beispiel der Drang noch ein weiteres Bier zu trinken oder stark überlernte Verhaltensgewohnheiten, wie zum Beispiel automatisch auf der rechten Straßenseite zu fahren unseren eigentlichen Zielen im Weg stehen. Dieser ´Wettstreit´ zwischen impulsiven oder habituellen Verhaltenstendenzen und zielgerichteten Handlungen wird auch als Konflikt bezeichnet.

Solch ein Konflikt tritt ständig in Erscheinung und kann viele Formen annehmen. Daher überrascht es nicht weiter, dass die Art und Weise wie Konflikt kontrolliert wird, auch sehr unterschiedlich sein kann. Es scheint offensichtlich, dass Menschen Konflikte ganz verschieden handhaben können: Wenn wir eine Konfliktsituation erwarten, können wir bereits vorausschauend zusätzliche Anstrengungen unternehmen um den Konflikt dann in der Situation adäquat zu lösen. Alternativ können wir solche Situationen auch bereits im Vorfeld vermeiden und umgehen damit die Gefahr, unseren Impulsen nachzugeben. Auch wenn wir mit einer Konfliktsituation bereits konfrontiert sind, können wir versuchen durch besondere Anstrengungen diesen Konflikt aufzulösen. Schließlich haben wir auch die Möglichkeit, uns aus der Situation zurückziehen wodurch wir das Risiko minimieren, entgegen unserer eigentlichen Ziele zu handeln.

Um diese Variabilität von Konfliktbewältigung besser zu verstehen, versucht die vorliegende Arbeit eine genauere Beschreibung dieser Kontrollprozesse zu geben. Zwei Dimensionen von

Kontrollfunktionen werden identifiziert. Diese ergeben sich aus teilweise antagonistischen Erfordernissen an erfolgreiche Handlungskontrolle und beschreiben zum einen die Abwägung zwischen Flexibilität und Stabilität, zum Anderen die Abwägung zwischen antizipativer Selektion und reaktiver Korrektur. Um zu erklären, wie diese beiden Dimensionen von Kontrollfunktionen interagieren und wie daraus ein adäquater Umgang mit Konflikten entstehen kann, wird das „Conflict Management Framework“ eingeführt. Eine Hypothese, die aus diesem Rahmenmodel hervorgeht, beschreibt eine spezifische Strategie mit Konflikt umzugehen, die in dieser Art noch nicht untersucht wurde: Wenn Konflikt erlebt wird, ziehen sich Personen aus dieser Situation zurück und versuchen dadurch dem Konflikt zu entgehen.

Der empirische Teil der Arbeit untersucht diese Verhaltensstrategie in Bezug auf Konflikterleben und testet, ob Personen unter bestimmten Bedingungen sich aus Konfliktsituationen zurückziehen. Im Rahmen dieser Untersuchung werden drei Reihen an Experimenten vorgestellt die sowohl Freie-Wahl Paradigmen, Klassifikationsaufgaben unter Zeitdruck, als auch die Aufzeichnung kontinuierlicher Bewegungen umfassen. Es zeigte sich, dass Konflikt motivationale Vermeidungstendenzen hervorruft (Experimente 1 und 2), Entscheidungsverhalten verzerrt, so dass kurzfristig mit Konflikt assoziierte Aufgaben vermieden werden (Experimente 3 und 5), und die Ausführung von komplexen Handlungen beeinflusst (Experimente 6 und 7).

Diese Ergebnisse unterstützen das vorgeschlagene Rahmenmodell und ermöglichen eine vertiefte Auseinandersetzung mit der Frage, wie unterschiedliche Konfliktbewältigungsstrategien integriert werden können. Dazu wird ein konnektionistisches Modell vorgestellt, dass die parallele Anwendung von zwei unterschiedlichen Strategien zur Konfliktbewältigung ermöglicht und damit die empirischen Befunde der Experimente 3, 4 und

5 erklären kann. Im verbleibenden Teil der vorliegenden Arbeit werden Fehler einer solchen Integration von Konfliktbewältigungsstrategien analysiert. Es wird diskutiert, in wie fern das vorgeschlagene Rahmenmodell mit spezifischen klinischen Störungen vereinbar ist. Außerdem wird darauf eingegangen, wie interindividuelle Unterschiede hinsichtlich der Art und Weise Konflikte zu meistern, mit Hilfe eines solches Modells besser erklärt werden könnten. Schließlich wird ein Versuch unternommen, so genannte Selbstkontroll-Fehler durch eine mangelhafte Dynamik unterschiedlicher Konfliktbewältigungsstrategien zu erklären.

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Summary

Humans have a remarkable ability to plan ahead, set goals for the future and then to act accordingly. Unfortunately, this is not always the case. Everybody has experienced situations in which motivational urges like a tendency to drink another beer, or over-learned behavioral routines like driving on the right side of the road collide with ones´ goals. This tug of war between impulsive or habitual action tendencies and goal-directed actions is called a conflict.

Conflict is ubiquitous and comes in many different ways. Not surprisingly, the means to control conflict are diverse, too. Clearly, people can manage conflict in multiple ways: When expecting a conflict situation to occur in the future, one can recruit more effort to resolve the conflict, for instance by inhibiting unwanted urges or habits. Alternatively one can avoid the conflict situation and thereby circumvent possible failures to control habits and impulses. Furthermore, when currently facing a conflict, people can mobilize more effort to overcome the conflict. Alternatively they can withdraw from the conflict situation to minimize the risk of indulging in their impulses and habits.

To account for these different ways to master a conflict, the present thesis takes an initial step towards a characterization of the variability of control. To this aim, two dimensions of control will be identified that result from partially incompatible constraints on action control. These dimensions depict a trade-off between flexibility and stability and between anticipatory early selection and reactive late correction of control parameters. To describe how these control trade-offs interact and to explain how conflict is handled to ensure adaptation behavior, the

conflict management framework is proposed. A corollary of this framework suggests that one strategy to control conflict comprises of a tendency to withdraw from a conflict situation.

The empirical part probed this behavioral response to conflict and tested whether participants withdraw from conflict situations. To approach this hypothesis, three series of experiments are presented that employ free choice paradigms, speeded response classification tasks and continuous movement tracking tasks to reveal withdrawal from conflict. Results show that conflict caused motivational avoidance tendencies (Experiment 1 &2), biased decision making away from conflict tasks (Experiment 3 & 5) and affected the execution of more complex courses of action (Experiment 6 & 7).

The results lend support for the proposed conflict management framework and provide the ground for a more thorough treatment of how the different conflict strategies can be integrated. As a first step, a connectionist model is presented that accounts for the simultaneous implementation of two conflict strategies observed in Experiments 3 – 5. The remainder of the present thesis analyses failures to integrate different conflict strategies. It is discussed how the conflict management framework can shed light on selected psychopathologies, inter-individual differences in control and break-downs of self-control.

Chapter 1

Executive control: From Basic Mechanisms to Self-Control

Executive control, the ability to regulate ones´ own thoughts and behavior according to internal goals is a remarkable feature of humans. Exercising control is a core aspect of adaptive behavior and becomes necessary in situations in which goal directed actions and habitual or impulsive actions collide (Posner & Snyder, 2004). The processes that constitute executive control have been the focus of an impressive research program and gave rise to several theoretical proposals (e.g. Botvinick, Braver, Barch, Carter, & Cohen, 2001; Carver & Scheier, 1981, 2001; Logan & Gordon, 2001; Norman & Shallice, 1986). The ability to control impulses and habits in childhood is highly predictive for success and well-being in later life (Moffitt et al., 2011). However, failures of control in healthy individuals and patients can have severe effects (Aron, Robbins, & Poldrack, 2004; Barkley, 1997; Baumeister, Heatherton, & Tice, 1994) and cause enormous cost for individuals (Tangney, Baumeister, & Boone, 2004), companies (Stutzer & Frey, 2006) and society (public healthcare: Schroeder, 2007; education: Moffitt et al., 2011; crime: Gottfredson, 1990). Thus, it is not surprising that several intervention programs aim to improve control deficits (Baumeister, Gailliot, DeWall, & Oaten, 2006; Diamond, Barnett, Thomas, & Munro, 2007; Klingberg et al., 2005). Thus, a better understanding of the mechanisms and features of control is needed. In the remainder of the chapter, I will briefly outline different approaches to study executive control. Then I will dissect out how these different theoretical approaches converge on some basic assumptions about control processes.

1.1 Control through the Lenses of Cognitive and Social Psychology

Theoretical models that aim to explain the control of thoughts, emotions and behavior advanced mostly in separation in the field of cognitive psychology and the field of social and personality psychology (cf. Hofmann, Schmeichel, & Baddeley, 2012). Control from a cognitive perspective is mostly concerned with conflicts that arise between highly over-learned, automatized actions and more controlled goal directed actions (Shiffrin & Schneider, 1977). To probe conflict between habitual action tendencies and goal directed action, so-called interference tasks are used in which selection of a correct response to a target conflicts with automatic response tendencies instigated by an irrelevant task feature. For instance, in the Stroop task (Stroop, 1935) for a review see (MacLeod, 1991) participants have to indicate the ink colorof a word regardless of the meaning of the word (e.g. the word RED printed in green). Responses are typically faster and less error-prone when the irrelevant feature affords the same response as the target (congruent trials) compared to when the relevant and irrelevant stimulus features afford different responses (incongruent trials). One of the most influential accounts of cognitive control has been put forward by Botvinick and colleagues (Botvinick et al., 2001; Botvinick, Cohen, & Carter, 2004; see Box 1). According to this model, conflict between competing response tendencies is detected and signals the need for additional control resources, which are subsequently recruited to bias task representations according to the current task demands (Kerns et al., 2004). Specifically, a conflict is solved by strengthening the representation of relevant task features (Egner & Hirsch, 2005) and by weakening and/or inhibiting (Stürmer, Leuthold, Soetens, Schröter, & Sommer, 2002) the representation of irrelevant task features. The elegancy of such a monitoring mechanism is that it works without the need to refer to any ´controller´ or homunculus (cf.(Monsell & Driver, 2000).

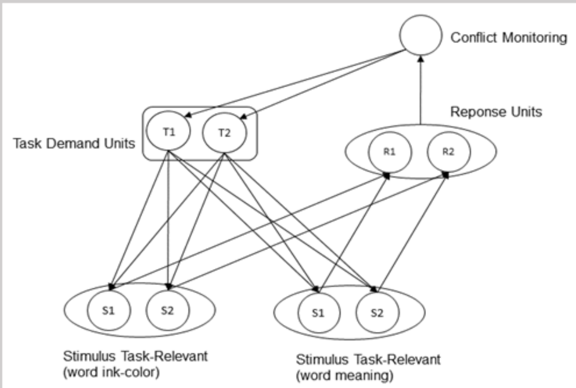
Box 1. The Conflict Monitoring Modell

The conflict monitoring model (Botvinick et al., 2001) is a successor of previous connectionist models that aimed to explain Stroop performance (e.g. Cohen, Dunbar, & McClelland, 1990). Connectionist models consist of several processing units which receive and send input to other units. In the model differently weighted connections transform input values and can result in excitatory or inhibitory connections (Rummelhart, McClelland, & Group, 1986).

The conflict monitoring model assumes separate input (i.e. stimulus representation, denoted S1 & S2) and response layers (R1 & R2). The input layer is influenced by a task demand unit (denoted T1 & T2), responsible for the implementation of the appropriate task goals. For instance, in a Stroop task, T1 codes for the relevant dimension which comprises the ink color of the word and T2 codes for the irrelevant dimension which comprises the word meaning. Now, on a given trial, stimulus units receive input from the perception of a two dimensional color-word.

Critically, the relevant dimension affords a left response, whereas the irrelevant dimension affords a right response.These diverging response tendencies cause a conflict at the response unit. Botvinick and colleagues added a so called ´conflict-monitor´ to previous models.

The conflict-monitor detects conflict at the response unit and calculates the relative strength of the conflict signal as a function of the activation of mutual exclusive responses. The conflict signal is passed on to the task demand unit to bias information processing towards the goal relevant dimension in the next trial by amplifying task-relevant dimensions (Egner & Hirsch, 2005) and inhibiting task-irrelevant dimensions (c.f. Stürmer et al., 2002; Botvinick et al., 2001; Gratton et al., 1992; see Scherbaum, Fischer, Dshemuchadse, & Goschke, 2011, for evidence of conflict adjustment within a trial).



The concept of monitoring has recently gained some interest in social theories on self-control (Inzlicht & Schmeichel, 2012; Myrseth & Fishbach, 2009). Self-control[1] typically refers to an internal conflict between a motivational impulse to maximize pleasure and/or to minimize displeasure and a planned behavior that is controlled by intentions (for an overview, see Hofmann, Friese, & Strack, 2009; Muraven & Baumeister, 2000; Trope & Fishbach, 2000). To illustrate a typical example of a self-control conflict, imagine a person with the goal to lose weight who is confronted with a sweet, high caloric cake. A central feature of self-control is the ability to override automatic impulses by replacing the impulsive action with a behavioral plan that is of greater importance than the impulsive response (Baumeister, 2002; Diamond, 2013, but see Ainslie, 1975; Fujita, 2011; Mischel, Shoda, & Rodriguez, 1989). For the last two decades interest in self-control has been strongly influenced by a focus on the inherent capacity limitations of control processes. Seminal work by Baumeister and colleagues on the sequential depletion of control resources suggested that self-control failures are the consequences of an exhausted central capacity of will power (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Recently, more process oriented models of self-control emerged that highlight specific mechanisms like motivation and attention to explain how and when people refrain from giving in to temptations (Baumeister & Vohs, 2007; Inzlicht & Schmeichel, 2012). For instance, Inzlicht and Schmeichel (2012) aimed to account for the resource depletion effect by proposing that the performance of demanding tasks in sequence causes shifts in motivation and attention. More precisely, they reasoned that demanding tasks lead to

[1] Self-control refers to specific subset of self-regulartory functions (cf. Carver & Scheier, 2000; Hofmann, Schmeichel & Baddeley, 2012). More generally, self-regulation requires a standard of thoughts or behavior, a monitoring process that keeps track of potential discrepancies between this standard and the actual state, sufficient motivation to reduce these discrepancies and sufficient capacity to successfully achieve discrepancy reduction (Baumeister & Vohs, 2007).

increased motivation to act impulsively and to increased attention to reward-related cues (Inzlicht & Schmeichel, 2012).

1.2 The Why, When and How of Control

Despite of different methodological approaches and diverging conceptualizations, most models of control converge on some basics. First, theories of executive control acknowledge that control is vital because of a fundamental bottleneck of information processing and output control (Yeung, 2013). According to Allport (1980, cited from Botvinick et al., 2001) "fundamental issues are raised by the demands of conflict resolution and of controlling undesirable interactions: of keeping separate processes separate." Thus, conflict necessitates a gating mechanism that prevents chaotic interference. Second, theories converge on the assumption that in order to counteract conflict, conflict has to be detected in the first place (Botvinick et al., 2001; Myrseth & Fishbach, 2009). Such a monitoring function can specify when control is required. Finally, for any theory on executive control to be complete, it has to explain how to handle conflict. It is a common theme for models of cognitive and self-control to portray control processes as a conflict resolution mechanism that counteracts interference by prioritizing goal relevant information over distracting information.

The enduring persistence of goals is a remarkable feature that is essential to shield intentions from distracting information. Indeed, overcoming conflict is crucial for successful goal pursuit. However, human behavior is not only characterized by its persistence, but also by its flexibility (Allport, 1989). Goals can be achieved by multiple means, different goals have to be temporally prioritized over others because of changes in the environment and sometimes it is necessary to abandon some goals altogether.

Clearly, when facing a conflict situation, people can manage a conflict in seemingly opposing ways: They either can invest more effort in the current task to overcome the conflict (Ach, 1935; Hillgruber, 1912). Alternatively, they can avoid conflict and withdraw from the task (Hull, 1943; Tolman, 1932). Depending on the situational conditions, both of these seemingly antagonistic behaviors can be adaptive. Now, if one wants to account for this variability, it will be necessary to develop a framework that seeks to explain how conflict is mastered by multiple processes.

1.3 Overview of the Present Work

The present work takes an initial step towards characterizing the variability of these behavioral responses to conflict. More precisely, I will argue that control can manifest in seemingly antagonistic forms of behavior: (i) preservation against or (ii) adjustment to conflict and (iii) avoidance of (iv) or withdrawal from conflict.

This conceptualization was motivated by recent theorizing on a central evaluative function of conflict monitoring. As will be shown later, the notion that conflict is registered as an aversive event can reconcile different perspectives on decision making that describe avoidance/withdrawal from conflict and perspectives on action control that describe persistence to overcome conflict (Botvinick, 2007).

I will begin by reviewing evidence for the aversive nature of conflict. Then, I will introduce a novel framework of control that distinguishes between different behavioral strategies as responses to conflict. Empirical evidence supporting this division will be reviewed. As I will argue, evidence for one of the conflict management strategies is currently missing. Consequently, three series of experiments will be presented that provide an initial test of the conflict management framework by probing the hypothesized conflict strategy.

Chapter 2

Conflict as an Aversive Signal

The proposal that conflict evokes a negative arousal has been a recurring idea in psychology. Dating back to Dewey (Dewey, 1895) this notion was most prominently revisited by Festinger´s dissonance theory (1957). Since then several different theoretical approaches converged on the assumption that mutually exclusive, antagonistic cognitions (and actions) arouse some kind of negative affect (cf. Proulx, Inzlicht, & Harmon-Jones, 2012). In the following, I will briefly review these different theoretical approaches.

2.1 Theories, Conflict and Negative Arousal

According to Festinger´s cognitive dissonance theory, arousal is the result of a contradiction in propositional knowledge (Festinger, 1957). When the logical relation between different elements is inconsistent, a state of dissonance is triggered. The role of dissonance as a causal factor for negative arousal has been confirmed by studies that employed the so called misattribution procedure (Schachter & Singer, 1962). In a seminal study by Zanna and Cooper (1974) participants received a sugar pill (and an elaborated cover story) before to a dissonance was induced by another task. While some participants learned that the pill had side-effects possibly causing an anxious feeling, other participants learned that the pill had other, non-arousing side-effects. Critically, participants in the former group could attribute their negative arousal to the side-effects of the pill. Indeed, these participants showed reduced signs of dissonance, whereas participants in the no-side-effect group exhibited efforts to reduced dissonance.

Table 1. Overview of theoretical concepts that ascribe conflict an aversive quality.

Theory	*Type of Conflict*	*Example*	*Reference*
Cognitive Dissonance	between logical relations (propositions)	person standing in the rain and is not getting wet	Festinger, 1957
Ambivalence	between object evaluations	rain is good for flowers (+) & rain is cold (-)	Nordgren, van Harreveld & van der Pligt, 2006
Curiosity-Drive Theory	between actions, thoughts	deciding which key to press	Berlyne, 1960
Action Model of Cognitive Dissonance	between action tendencies	two equally valued alternatives	Harmon-Jones & Harmon-Jones, 2002
Fluency	between percept, concepts, actions	*Rain* vs. **Rain**	Reber, Winkielman & Schwarz, 1998
Logical Gut Feeling	between options under uncertainty	Base-rate problem	De Neys, 2014
Conflict Monitoring	between actions	SSHSS vs. HHHHH	Botvinick, 2007

Not only propositional knowledge of objects can lead to negative arousal, but also the evaluation of an object. In the case of ambivalence, the mental representation of an object includes attitudes towards the object that are positive *and* negative at the same time (cf. Gawronski, 2012; Nordgren, van Harreveld, & van der Pligt, 2006; van Harreveld, van der Pligt,

& Yael, 2009). However, holding two opposing attitudes towards an object in mind is not generally negative. According to the model of ambivalence-induced discomfort, only those attitudes that are simultaneously accessible and salient cause discomfort (van Harreveld et al., 2009). A typical situation that meets these requirements is a choice situation. Here, deciding between two ambivalent objects renders the outcome of a choice uncertain and results in anticipated regret and negative arousal (van Harreveld, Rutjens, Rotteveel, Nordgren, & van der Pligt, 2009)

Negative consequences of conflict can also result from low level processes like simple action plans. Berlyne (1957, 1960) proposed that response conflict, for instance in simple choice reactions, triggers emotional disturbance and arousal. By drawing on a theoretical analysis of information theory (Shannon & Weaver, 1949), he suggested that increasing entropy between multiple to-be-planed-responses causes an arousal signal, which gives rise to a motivation to avoid the source of conflict. Subsequently Berlyne´s thorough treatment of conflict became less influential after his general conception of a single arousal and reward has been criticized both on theoretical and empirical grounds (cf. Silvia, 2005; see also Berlyne, 1967). However, numerous studies that measured the skin conductance response while participants performed a Stroop task provided evidence for the arousing quality of conflict (Kobayashi, Yoshino, Takahashi, & Nomura, 2007; Naccache et al., 2005; Renaud & Blondin, 1997; Waid & Orne, 1982).

Harmon-Jones and colleagues proposed a model that links cognitive dissonance and response conflict (Harmon-Jones et al., 2009; Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008). According to the action-based model of cognitive dissonance, cognitions are generally linked to action tendencies. Thus, inconsistent cognitions automatically cause conflict between actions. Consequently “negative affect results because it [conflict] has the potential to interfere with effective actions” (Harmon-Jones et al., 2009, p.128). A similar view of negative affect as a consequence of crosstalk in action control has been raised by Morsella and colleagues (Morsella, Feinberg, Cigarchi, Newton, & Williams, 2011; Morsella, Gray, Krieger, & Bargh, 2009). In a series of experiments, participants rated incongruent Stroop trials as more effortful and more negative than congruent Stroop trials, thus providing evidence for the subjective experience of negative tension during response conflicts.

In a different line of research, the role of effortful encoding or retrieval has been conceptualized as a result of processing fluency (Reber, Schwarz, & Winkielman, 2004). Fluency refers to the ease or difficulty of processing, which includes - among other domains - perception (Reber, Winkielman, & Schwarz, 1998), conceptual reasoning (Novemsky, Dhar, Schwarz, & Simonson, 2007), memory retrieval (Tversky & Kahneman, 1973) and action execution (Casasanto & Chrysikou, 2011, see Alter & Oppenheimer, 2009 for a review). It is assumed that the fluency signal is hedonically marked, with dis-fluent stimuli giving rise to a negatively connoted feeling. This signal can be accessed by a metacognitive process (Winkielman, Schwarz, Fazendeiro, & Reber, 2003). Therefore, fluency is used as a cue for various judgments (Alter & Oppenheimer, 2009). For instance, when participants have to rate their preferences for different stimuli, stimuli which are processed dis-fluently, like hard to read fonts or low contrast pictures are evaluated more negatively compared to easy to read fonts or high contrasts pictures (Reber, Winkielman & Schwarz, 1998).

Research on problem solving found that participants experience negative arousal during reasoning tasks like the base rate problem (De Neys, Moyens, & Vansteenwegen, 2010). Here participants had to decide between two options that have different reward values and different probabilities for winning the reward. Critically, in conflicting situation the task was constructed in a way that an automatic heuristic response was facilitated. This heuristic was antagonistic to the application of basic logical or probabilistic principles. This conflict between intuition and deliberation is assumed to be effortful (De Neys & Glumicic, 2008). Furthermore, upon presentation of these conflict-problem-tasks the skin conductance response was elevated, indicating that overcoming heuristic thinking caused arousal (cf. De Neys et al., 2010; De Neys, Vartanian, & Goel, 2008).

Recently, a revised version of the conflict monitoring model (Botvinick 2007; see Box 2 for details) ascribed conflict an aversive quality. Supportive evidence for a negative evaluation of conflict comes from a behavioral study of Dreisbach and Fischer (2012; Fritz & Dreisbach, 2013). In this study, congruent and incongruent Stroop displays served as primes that were presented prior to a clearly valenced positive and negative target word. The participants' task was to classify the valence of the positive or negative target word as quickly and as accurately as possible (affective priming task, Fazio, Powell, & Williams, 1989). Results showed that the congruency level of the Stroop primes affected performance in the evaluative categorization task: RTs for negative targets were shorter with incongruent Stroop primes and longer with congruent Stroop primes, and vice versa with RTs for positive targets. These findings suggest that (Stroop) stimuli associated with conflict are evaluated negatively.

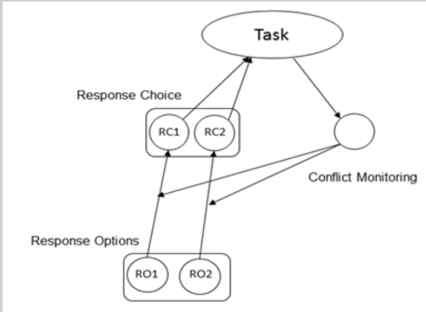
To conclude, the idea that conflict detection leads to a negative affective state has been a common theme in psychology for over 60 years and empirical results from a wide range of research strands have accumulated in support for this notion. How the aversive quality of conflict is used to guide control will be considered in more detail in the next section.

2.2 One Signal, Different Consequences

Research on dissonance, response conflict, fluency and problem solving differs widely in the way how conflict is induced. Interestingly, studies that examined the neural activity during the performance of these tasks converge on the observation, that activity in the anterior cingulate cortex (ACC) is increased during performance in conflict trials relative to non-conflict trials (Carter et al., 1998; De Neys et al., 2008; Van Veen, Krug, Schooler, & Carter, 2009). This neural activity has been interpreted as evidence for a conflict detection function of the ACC (Botvinick et al., 2001, 2004). Research has also shown that the ACC is involved in affective and motivational processes during decision-making (Carter, Botvinick, & Cohen, 1999; Holroyd & Coles, 2002; Holroyd & Yeung, 2012; Shackman et al., 2011). For instance, lesions of the ACC have been shown to cause *akinetic mutism*, a neurological disorder that is characterized by a strong reduction of motivated action despite intact motoric abilities (Németh, Hegedüs, & Molnâr, 1988). Finally, another line of research ascribes the ACC a critical role as a detection system for aversive events like pain or social exclusion (Eisenberger, Lieberman, & Williams, 2003; Rainville, 2002; for a review see Shackman et al., 2011).

Box 2. The Demand Avoidance Modell

Botvinick (2007) proposed a model to account for the finding that participants gradually learned to avoid a response option that was frequently associated with a high level of conflict (see also Kool et al., 2010; for a more detailed description see **section 3.3.3**). The model consists of a response option layer, comprising of RO1 and RO2. These response options are connected to response choice units (denoted RC1 & RC2). The conflict task is modelled as a hidden layer which can result in a conflict or non-conflict trial. Like in the conflict monitoring model (Botvinick et al., 2001; see Box 1), conflict is detected by a conflict monitoring unit.
How does the model ´learn´ to avoid conflict associated response options? According to Botvinick (2007) the detected conflict signal propagates to the connection weights that are interposed between R01 and RO2 and RC1 and RC2, respectively. The weights of these connections are updated after each trial according to the level of conflict associated with each response option (and according to a learning parameter). Consequently, response choices are biased away from response options that are associated with high levels of conflict.



To reconcile these diverging findings, Botvinick (2007; Shenhav, Botvinick, & Cohen, 2013) proposed an integrative model of ACC function. Central to this model is the assumption that conflict is registered as an aversive event. On the one hand, the negative signal is used as a teaching signal to bias decision making away from the source of conflict. On the other hand, the detection of conflict allows for the adjustment of control settings to resolve conflict. Obviously, these are seemingly opposing behavioral responses to conflict.

In the following chapter, I put forward a framework of cognitive control that builds on the assumption that conflict is detected as an aversive signal and subsequently harnessed to guide adaptive action control. However, adaptive actions in response to conflict can take very different forms. The proposed *conflict management framework* aims to account for this intra-personal variability by proposing a taxonomy of different strategies to control conflict.

Chapter 3

Dealing with Conflict: The Conflict-Management Framework

The current account of control focuses on the question *how* conflict is managed to ensure successful adaptation to conflict. At the core of the conflict management framework is the distinction between two dimensions of control. These dimensions result from partially incompatible constraints on action control (Braver, Gray, & Burgess, 2007; Braver, 2012; Goschke, 2013).

The first dimension describes a trade-off between flexibility and stability. On the one hand, goals must be maintained in the face of obstacles to ensure successful goal pursuit. On the other hand, the means to achieve a certain goal or even the goals themselves have to be flexible to adapt to an ever-changing environment. I will denote the control modes that realize opposing manifestations of the stability-flexibility trade-off as assimilative and accommodative control (cf. Brandstätter & Rothermund, 2002). The *assimilative* control mode describes mechanisms to persist on the current task and to adjust efforts to overcome a conflict (Ach, 1935; Botvinick et al., 2001). In contrast, the *accommodative* control mode comprises mechanisms to withdrawal from the current task and to circumvent conflict by avoiding the conflict-inducing situation (Hull, 1943; Botvinick, 2007).

The second dimension describes a trade-off between anticipatory early selection and reactive late correction of control. On the one hand, advance preparation enables optimal performance in stable contexts. On the other hand, spontaneous changes in the environment and the encounter of novel stimuli require on-demand adjustments of control. I will denote the control modes that realizes the opposing manifestations of the sustained-transient trade-off as proactive and reactive control (cf. Braver, Gray, & Burgess, 2007; Braver, 2012) *Proactive* control describes the sustained maintenance of goal relevant information before a critical stimulus has been processed. In contrast, *reactive* control describes a transient activation of goals after a critical stimulus has been processed.

By describing how these control trade-offs interact, the present framework substantially refines earlier accounts of cognitive control (e.g. Botvinick et al., 2001; Botvinick, 2007) that eclectically focused on only one particular dimension or a single conflict strategy. Thus, the motivation of the present framework is to gain more insight into a mechanistic understanding of executive control by focusing on the variability how conflict situations are mastered. To this end, I will suggest that the combination of different trade-offs result in different strategies[2] of flexible *conflict management.* In the next section, the conflict management account is outlined

[2] "Strategy" is used in line with Gratton, Coles and Donchin (1992, p. 480) who stated that in conflict situations "the choice of the level of processing to adopt for initiating or completing overt responses, or both, may be strategic: That is, several courses of action are possible, and the subject´s choice of which course of action to adopt is dictated by an analysis of the costs and benefits (i.e. the relative utility) associated with each choice." Furthermore the authors´ clarify that the "choice of a strategy may be conscious or deliberate. However, this is not necessarily the case, because the selection of a particular strategy may reflect the operation of some adjustment mechanism that is not under conscious control." (Gratton et al., 1992; p. 480, see also Braver, Gray & Burgess, 2007 for a similar argument).

first by describing the two control trade-offs between different action constraints, before the interaction of both trade-off is described in more detail.

3.1 The Stability-Flexibility Control Trade-off

Successful goal pursuit requires sufficient stability to shield goals against distractions. One way to achieve stability is an assimilative control mode. For instance, prepotent impulses that interfere with the current goal have to be inhibited or overridden. Inhibition is considered as a core capacity of executive control (Miyake et al., 2000). To probe inhibition, interference task like the Stroop-task are used (Stroop, 1935, see section1.1 for more details).

At the same time, control has to be sufficiently flexible, to adapt to changes in the environment. This is achieved by an accommodative control mode. One essential capacity for flexible adaption is mental set shifting. It allows to react adaptively to changing environmental or internal demands and consequently to switch back and forth between different mental or task sets (Monsell, 1996). It is assumed that mental shifting is also necessary for creativity and cognitive flexibility in social interactions like perspective taking (Diamond, 2013). A standard task to probe mental shifting is the task-switching paradigm (Jersild, 1927; for a review see Kiesel et al., 2010). In a task switching experiment, participants perform different tasks according to specific stimuli and each task requires attending to a different dimension of the stimulus. For instance, when presented with a single digit between one and nine, one task could be an odd/even classification task and the other task could be a smaller/larger than five-classification task. The currently relevant dimension can be prespecified (e.g. Rogers &

Monsell, 1995) or cued (e.g. Meiran, 1996). The task sometimes changes and sometimes stays the same, causing task switches and task repetitions. Generally, responses on repetition trials are faster than on switch trials. Several explanations have been raised to account for these switch costs, but most agree that switch costs indicate some form of cognitive flexibility (Monsell, 2003). Flexibility becomes necessary for an accommodative control mode because it allows the disengagement from the current task and the reengagement in an alternative task.

3.2 The Sustained-Transient Control Trade-off

Control is recruited on different time scales. Working memory functions (Baddeley, 2007), like updating and maintenance of goal relevant information enable the system to keep track of which information is relevant for the task and which information can be replaced (Owen, McMillan, Laird, & Bullmore, 2005; Smith & Jonides, 1999). Shielding against distracting stimuli is most successful when control settings are specified in advance. To this end, goal relevant information has to be maintained in a sustained manner (cf. Braver et al., 2007). Sustained goal activation resembles a proactive control mode. This can be achieved by encoding context-relevant information that is used to bias processing according to the goal relevant dimensions (Braver, 2012). Sustained control is assumed to operate on a longer time scale and relies on learning processes, enabling participants to actively prepare for the upcoming stimulus event (Braver, Paxton, Locke, & Barch, 2009; Verguts & Notebaert, 2009). At the same time fast changing environments and unexpected contingencies make more spontaneous control mechanisms necessary (cf. Geng, 2014). In these cases, stimulus-driven, transient goal information has to be activated on very short timescales (Braver et al., 2009). Transient control configures control settings on demand to the current conflict situation and is achieved by a reactive control mode.

A recent model that accounts for these two qualitative different operation characteristics of control operations with different temporal dynamics has been proposed by Braver and co-workers (Braver et al., 2007; Braver, 2012, see also Duthoo, Abrahamse, Braem, & Notebaert, 2013; Geng, 2014; Koriat, Ackerman, Adiv, Lockl, & Schneider, 2013; Saunders & Jentzsch, 2013). According to the dual control mode (DCM) model control processes operate on a proactive and a reactive control mode (Braver 2012). Behavioral (Funes, Lupiáñez, & Humphreys, 2010) and neurophysiological evidence (Braver et al., 2009) has been accrued that provides evidence for a dissociation between these control operations.

Proactive control is concerned with the early selection of control relevant information. This is achieved by anticipating context associated control parameter. Proactive tuning of control happens *before* a stimulus has been processed. In contrast, reactive control is concerned with the late corrective adjustments of control parameter. This control mode operates on a very short time scale and enables a tuning of control *after* a stimulus has been processed.

3.3 The Conflict Management Strategies

Critically, these trade-offs reflect principle constraints of control (Goschke, 2013). The present conflict management framework suggests that both trade-offs are integrated to optimize this multiple constraint satisfaction problem. As can be seen in Figure 1, combining the two trade-offs results in four different strategies of conflict control. In the next section, I will detail each of the four strategies and review evidence in support of this taxonomy.

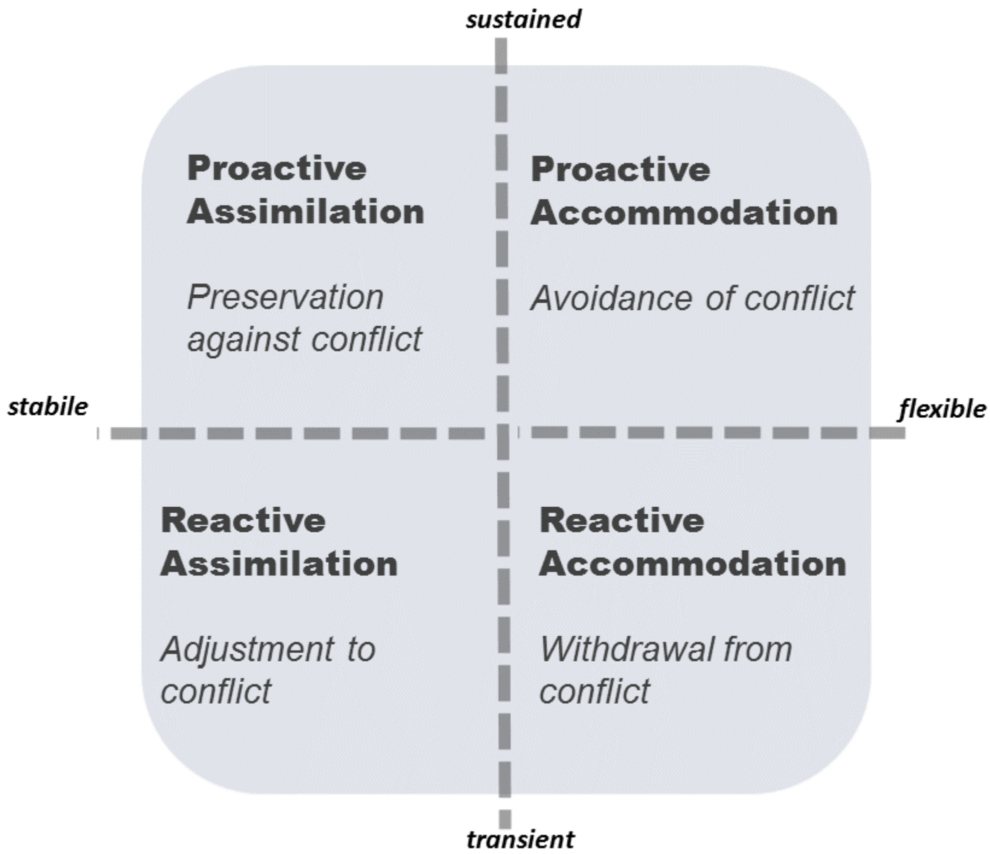


Figure 1. A graphical sketch of the four conflict management strategies. The vertical axis depicts a stability-flexibility control trade-off, the horizontal axis depicts a sustained-transient control trade-off. The postulated conflict management strategies are printed in bold. Each of them describes a different control mode in response to conflict (see main text for detials). Functional descriptions of the empirical findings that relate to the respective strategy are printed in italics.

3.3.1 Reactive Assimilation

The reactive assimilative strategy reflects increased effort to overcome a conflict as an immediate response to the conflict-inducing stimulus. . To illustrate this strategy, imagine a person who has made the new year´s resolution to eat fewer sweets. A reactive assimilation strategy can be conceived a counteractive control process that is activated just as the person enters a coffee shop and catches sight of a cake for the first time.

In cognitive control literature, such a reactive control strategy is studied by analyzing trial-to-trial variations of control in response to conflict. Gratton, Coles and Donchin (1992) demonstrated in a seminal study that the congruency level of the previous trial influences the size of the congruency effect. When the previous trial was incongruent, the congruency effect was reduced in the current trial compared to when the previous trial was congruent (so called Gratton effect; see also Akçay & Hazeltine, 2007; Kerns et al., 2004 for a review see Egner, 2008). A typical interpretation of the Gratton effect assumes that the detection of conflict between two planed responses in the actual trial causes a recruitment of additional control resources that mitigates conflict in the following trial (Botvinick et al., 2001; Egner, 2008; but see Hommel, Proctor, & Vu, 2004; Mayr, Awh, & Laurey, 2003; Schmidt & De Houwer, 2011 for alternative accounts). The Gratton effect is a well-established marker for increased persistence to resolve conflict and is sensitive to a broad range of cognitive control deficits (e.g. Clawson, Clayson, & Larson, 2013; Clayson, Clawson, & Larson, 2012; Clayson & Larson, 2013; Patino et al., 2013)

Recently, a variant of the Gratton effect has also been used to study implicit emotion regulation (Egner, Etkin, Gale, & Hirsch, 2008; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Gyurak, Gross, & Etkin, 2011). In this affective Stroop task, photographs of emotional facial expressions were presented with a word superimposed on the face. Participants were to indicate the emotion displayed by the face (e.g. happiness) and to ignore emotional word (e.g. anger) written on the photo. Analog to the color version of the Stroop-task, facial expressions and emotional words could match or mismatch. The authors reported a Gratton effect, indicative of an reactive assimilation strategy when controlling emotional information.

Reactive assimilation as indicated by the Gratton-effect has also been studied in stereotype behavior, a typical application of self-control. Numerous studies have conceptualized stereotype tasks in terms of response interference mechanisms (Amodio, Master, Yee, & Taylor, 2008; Bartholow, Dickter, & Sestir, 2006; Payne, 2001). For instance, Kleiman, Hassin and Trope (2013) intermixed a response interference task that provoked conflict in some trials with a classification task that assessed gender stereotypes. Responses to the classification task exhibited less stereotyping after previous conflict trials compared to previous non-conflict trial. These results show that reactive recruitment of control alleviates the behavioral expression of stereotypical biases.

To summarize, the reactive assimilative strategy allows a temporary boost in control to alleviate conflict. Critically, this increase in control operates ´on demand´ as a response to the experience of a conflict.

3.3.2 Proactive Assimilation

The proactive assimilative strategy requires that goal relevant information is held active in working memory from the moment of goal setting until the goal is reached and the intention can be deactivated. Consider again the coffee shop example. Whenever the person has lunch, she regularly has to withstand a delicious cake that is on offer. After a while the coffee shop will become a context that activates constantly the goal representation and thus facilitates inhibition of unwanted impulses to order the cake.

In the literature on cognitive control, sustained proactive control is examined by a manipulation of the context in which conflicts occur. For instance, changes in the proportion of congruent to incongruent trials in the Stroop task influence the ability to suppress and override the irrelevant dimension of a Stroop stimulus as revealed by a modulation of the congruency effect. In contexts with a high proportion of congruent trials, word meaning and print color of the words match most of the time and cause a speed up of responses on congruent trials and a slow-down of responses in incongruent trials (Crump, Gong, & Milliken, 2006; Funes et al., 2010; Gratton, Coles, & Donchin, 1992; Logan & Zbrodoff, 1979). This finding has been interpreted to reflect a sustained change in the reading strategy. Participants become more efficient in attending to the word meaning in contexts with a high proportion of congruent trials whereas in contexts with low proportion of congruent trials participants become more efficient in ignoring the word meaning (cf. Logan & Zbrodoff, 1979; but see Jacoby, Lindsay, & Hessels, 2003; Schmidt & Besner, 2008 for an alternative account).

A similar manipulation of the proportion of congruent to incongruent trials has been used to study proactive control in stereotyping. In a study by Bartholow and Dickter (2008) participants had to categorize the race of a centrally presented target face that was flanked by distracting words. These words were either congruent or incongruent to the stereotype associated with the face. Critically, the proportion of congruent to incongruent trials was manipulated. Results resembled the pattern of the ´cognitive´ proportion congruency effect (see above), with a larger compatibility effect in contexts with a high proportion of congruent trials compared to contexts with a low proportion of congruent trials. Similar to findings on the color Stroop proportion congruency effect, the authors interpreted their findings as to reflect a sustained change in attentional allocation to the stimuli that elicit responses associated with stereotype behavior.

To conclude, proactive assimilation refers to the sustained activation of goals by context factors. The context factors are learned over longer periods and enable the anticipation of a conflict situation even before the conflict takes place.

3.3.3 Proactive Accommodation

A different strategy to deal with conflict is proactive accommodation. This strategy describes anticipatory avoidance of a conflict situation. Similar to proactive assimilation, the proactive accommodative strategy requires that goal relevant information is actively maintained through context associations. Imagine once more the person with the goal to eat fewer sweets. After having learned that her favorite coffee shop has a delicious cake on offer, when thinking of the coffee shop (the context factor) she will anticipate the conflict and avoid the coffee shop.

Evidence for this strategy comes from studies that probe decision-making. Botvinick and co-workers developed task procedures in which participants can choose between two response options that were associated with different levels of conflict (Botvinick & Rosen, 2009; Kool, McGuire, Rosen, & Botvinick, 2010, see also Schouppe, Ridderinkhof, Verguts, & Notebaert, 2014). When participants experienced conflict frequently in one task and less frequently in another task, they preferred the easier task and choose the effortful one less often. These experiments show that people learn to avoid conflict over time when possible.

Another line of research investigated the modulation of the error-related negativity (ERN), a negative deflection in the event related potential that peaks shortly after subjects made in incorrect response (Gehring, Coles, Meyer, & Donchin, 1995) or after subject received feedback that is indicative of an error (Miltner, Braun, & Coles, 1997). Nieuwenhuis, Yeung, Holroyd, Schurger and Cohen (2004) used a gambling task to demonstrate that the ERN is sensitive to reward and punishment signals and general performance feedback. The authors concluded that the ERN is functional equivalent to a reward prediction error signal that biases subsequent task selection in the upcoming task (see also Frank, Woroch, & Curran, 2005). Theories have explained such avoidance effects with reinforcement learning theory (Holroyd & Coles, 2002). ACC registers and evaluates (negative) outcomes and uses this information for action selection.

In the literature on social and personality psychology, the proactive accommodation strategy is sometimes referred to as preventive self-control (Hofmann & Kotabe, 2012) or proactive coping (Aspinwall & Taylor, 1997). Here, anticipation of tempting situations like the one illustrated with the cake example, causes participants to avoid these situations or eliminate temptations even before they can interfere with goals (Schelling, 1984). The ability to identify potential threads for successful self-control before exposure to potential temptations has been the focus of behavioral intervention programs for quite some time (cf. Hofmann & Kotabe, 2011). Indeed, recent field research suggests that people who have high trait self-control abilities are not particular good in resisting temptations, but they successfully avoid self-control demanding situations in the first place (Hofmann, Baumeister, Förster, & Vohs, 2012).

Thus, when the context is held active, proactive accommodation is the ability to anticipate conflict situations and to avoid these situations in the future. This strategy bypasses conflict and therefore eliminates possible self-control failures very successfully. As for the proactive assimilative strategy, context factors have to be learned to enable the anticipation of conflict situations.

3.3.4 Reactive Accommodation

Finally, reactive accommodation is the least researched conflict management strategy. This strategy recruits control ´on demand´ to disengage from the task at hand and eventually withdrawal from the conflict situation. In the coffee shop example, the reactive accommodation strategy suggests that after an initial exposure to the cake and a beginning struggle not to order it, the person would experience the tendency to avert her eyes from the cake or even to immediately leave the coffee shop.

So far, the evidence for the reactive withdrawal from conflict is only suggestive. For instance, Botvinick (2007) assumed that in the demand avoidance task, the association between conflict and a task is established gradually over time. In addition, he speculated that more recent conflict could have a stronger impact on learning than conflict several trials back. However, this idea had not been tested yet.

Research on self-control demonstrated that participants who formed a long term goal showed stronger approach reactions to the goal in question and stronger avoidance reactions when confronted with hindering temptations (Fishbach, Friedman, & Kruglanski, 2003; Fishbach & Shah, 2006). For instance, in a study by Fishbach and Shah (2006) participants were to respond with approach or avoidance movements to goal- and temptation-related target words. Participants who had formed a specific goal (e.g. to diet) responded faster with avoidance movements to temptation-related stimuli (food words) and with approach responses to goal-related stimuli (fitness words).

These results, e.g. faster avoidance reactions to temptations have been interpreted to indicate automatic activation of relevant goals. Alternatively, the facilitation of avoidance reactions might have resulted from a tendency to withdraw from a conflict situation. It should be noted that these two interpretations are not mutually exclusive. Indeed, when facing a tempting stimulus, participants could experience conflict only, if the relevant goal was activated. However, the postulated mechanisms differ. Fishbach and Shah (2006) suggested that tempting stimuli acquire motivational relevance. An alternative explanation according to the conflict management framework would assume that tempting stimuli acquire their tempting character only in contrast to a goal and that this conflict between temptation and goals triggered avoidance.

Despite these speculations, no study had tested yet whether conflict triggers a tendency to withdrawal from the conflict situation. However, a conflict management account would necessarily predict that people make use of this strategy. The next chapter will outline the rational for a systematic test that can provide evidence for a reactive accommodation.

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Chapter 4

The Present Research: Reactive Withdrawal from Conflict

A central hypothesis of the proposed conflict management framework is that adaptive control comprises a repertoire of different conflict strategies. One of these strategies is a reactive accommodation strategy. It allows flexible withdrawal from conflict provoking situations.

4.1 Theoretical Neglect of Reactive Withdrawal

As set out above, empirical evidence for this strategy is scarce. Firstly, this is partly due to a strong focus on persistence. Indeed, the idea that persistence is crucial to success is deeply embedded in western culture and proverbs like "winners never quit, and quitters never win" capture this sentiment. The popular enthusiasm for persistence is also reflected in scientific theories of control, which largely neglect adaptive disengagement from a task (cf. Brandstädter & Rothermund, 2002; but see Wrosch, Scheier, Miller, Schulz, & Carver, 2003). For instance, this prevailing focus on persistence is expressed by an influential analysis of self-control by Baumeister and colleagues when they state, "it is an instructive exercise to try to reduce all self-control regulation to self-stopping. […] one can analyze the vast majority of instances of self-regulation in that way (Baumeister et al., 1994, p. 7).

4.2 Empirical Neglect of Reactive Withdrawal

Secondly, the scarce evidence for reactive assimilation is due to the operationalization of control processes in experimental paradigms. For instance, flexibility has become a central topic in the literature on cognitive control by studying the ability to switch between different tasks (Monsell, 2003). However, in the classical task-switching paradigm, withdrawal from conflict is not possible because conflict is caused by the requirement to switch between task sets (see section 6.4 and 9.2 for a more detailed treatment of this point). Thus, experimental protocols employed so far are insensitive to withdrawal from conflict. More precisely, most paradigms principally cannot provide evidence for a reactive accommodation strategy, because participants are not given the opportunity to disengage or withdraw from the task.

4.3 Overview of the Empirical Part

Thus, what is missing is a paradigm that provides empirical evidence for a reactive accommodation strategy. To this end, I will present three experimental series that address different aspects of withdrawal from conflicting situations. In contrast to previous research, the present experimental protocols are carefully designed to probe withdrawal from a conflict situations by providing the opportunity to choose means to escape conflict (e.g. free choice test in Experiments 2 - 5) or to come up with sensitive measures that reveal ongoing withdrawal tendencies during action execution (e.g. continuous movement analysis, Experiment 6 & 7).

Consequently, Experimental series A tested whether conflict facilitates avoidance motivation relative to approach motivation. I reasoned that basic motivational action tendencies like approach and avoidance would provide means to withdraw from a conflict situation. Participants first performed a Stroop interference task. During this induction phase, stimuli became associated with different levels of conflict. In a subsequent approach-avoidance test phase the previously conflict-loaded stimuli were presented, and participants reacted according to a specified mapping (Experiment 1) or could freely select whether to react with either an approach or an avoidance response (Experiment 2). This first series of experiments was designed to establish the basic phenomena of withdrawal from conflict.

Experimental series B approached the reactive accommodative strategy from a decision-making perspective. I reasoned that an alternative way to implement the reactive accommodative strategy would be to bias decision making away from the source of conflict. Hence, participants could freely choose between two distinct response interference tasks. Task switch rates provide a direct test whether participants withdraw from conflict. Importantly, conflict in both tasks was equally frequent. This ruled out any proactive accommodative strategy (e.g. learning to associate one task with more conflict). Furthermore, by analyzing task choices and task performance in trial-to-trial variations (a Gratton effect). Experimental series B also tested the jointly implementation of reactive assimilation and reactive accommodation strategies.

Experimental series C tested whether the initial tendency to withdraw from conflict could be observed in the movement execution, even though participants were forced to perform a specific action that involved a conflict. This setup provides a particular strong test of the reactive accommodative strategy because participants cannot freely select between different motivational actions (Experiment 1 &2) or different courses of actions (Experiment 3 -5). I hypothesized that a careful analyses of the way in which an action in a conflict situation is executed might provide a window into the dynamics of flexible conflict management. This analysis is based on the reasoning that the tug-of-war between antagonistic action tendencies is not ultimately solved before movement initiation but leaks into action execution. To this end, I measured mouse trajectories during the resolution of a self-control conflict to quantify the dynamic tendency to withdrawal. Furthermore, to extend this line of research from cognitive conflict situations that resulted from response interference tasks to more typical self-control situations, this series of experiments employed a self-control dilemma that resulted from a conflict between short-term impulses and long-term goals.

The following chapter is based on:

Dignath, D. & Eder, A. (under review). Conflict triggers aversive motivation.

Chapter 5

Experimental Series A – Withdrawal from Conflict

The first series of experiments examined whether a reactive accommodation strategy results in basic motivational action tendencies, for instance avoidance as a response to conflict. Experiments 1 and 2 tested this conjecture by combining a conflict task with a approach-avoidance test (Chen & Bargh, 1997; Eder & Rothermund, 2008). According to the revised conflict monitoring account, detection of a conflict should cause a negative evaluation of the conflict-inducing situation (Botvinick, 2007). As described above in more detail, evidence has accumulated in favor of this notion (cf. Dreisbach & Fischer, 2012; Fritz & Dreisbach, 2013). However, the negative quality of conflict does not necessarily facilitate avoidance of the source of conflict. Animal and human research pointed out that one must be cautious in the inference of motivational urges from measurements of affective experiences because (i) negative stimuli can also evoke a motivational urge to approach (Berkowitz & Harmon-Jones, 2004; Carver & Harmon-Jones, 2009; Scholer & Higgins, 2008) and (ii) approach motivation is occasionally experienced as a negative affective state (Berridge, Robinson, & Aldridge, 2009; Carver, 2004; Harmon-Jones, Harmon-Jones, & Price, 2013). In short, approach and avoidance motivations are dissociable from positive and negative affective states; consequently, more direct evidence is needed to evaluate the theoretical claim of a motivational avoidance of conflict-inducing stimuli.

5.1 Experiment 1

The experiment consisted of two separate phases to disentangle cognitive control processes from an assessment of motivational urges: a conflict-induction phase and a motivation test phase. In the induction phase, participants performed a color-Stroop task, in which congruent and incongruent Stroop stimuli induced low and high levels of conflict, respectively. In a subsequent test phase, participants performed an approach-avoidance task (AAT). In this task participants responded to the Stroop stimuli with approach- and avoidance-related lever movements (Chen & Bargh, 1997; Eder & Rothermund, 2008). Importantly, participants were to respond in this task to both dimensions of the Stroop stimuli — the ink color *and* the meaning of the word — by sorting these stimuli into (congruent) one-color words and (incongruent) two-color words. Thus, there was no response competition during the motivational test phase (cf. Brown, 2009). In one task block, participants responded to one-color words with an approach-related lever movement and to two-color words with an avoidance-related lever movement; in a second task block, the stimulus-response mapping was reversed (with the order of the task instructions being counterbalanced across blocks).

According to the conflict management account and Botvinick's integrative model (2007), I predicted for the AAT an interaction between stimulus type (incongruent vs. congruent) and response type (approach vs. avoidance). More precisely, one-color words associated with no conflict in the previous Stroop task should facilitate approach responses relative to avoidance responses in the subsequent task, while two-color words associated with a high level of conflict in the induction task should facilitate avoidance relative to approach. In addition to this interaction effect, I examined with correlation analyses whether participants who experienced strong conflict in the first phase (as indexed by increased error rates for incongruent relative to congruent word-color displays in the Stroop task) also show a stronger bias to avoid two-color stimuli and to approach one-color words in the subsequent motivation test.

5.2.1 Method

Participants

Forty-two students at the University of Würzburg were paid for participation (42 women, 5 left-handed, 18–38 years). Participants were naive to the purpose of the experiment. Data of two participants were removed from analyses due to unusual high error rates in the AAT (*M* = 41%, > 3 SDs of the group mean *M* = 10.4%).

Stimuli

Color-words for the Stroop task were the German words for “BLUE”, “GREEN”, “YELLOW” and “RED” printed in blue, green, yellow and red. In congruent Stroop trials, the print color of the word matched the meaning of the word; in incongruent trials, both print color and word meaning mismatched. Only four combinations of incongruent Stroop displays were presented to a participant to ensure presentations of congruent and incongruent Stroop stimuli in equal frequencies. For these incongruent color words, the assignment of the ink color to the color words was counterbalanced across participants. Words were written in Calibri and subtended 21.36° (width) x 5.87° (height) of visual angle measured from a viewing distance of 50 cm. A white cross subtended 1.15° of visual angle in width and height and was presented as a fixation sign.

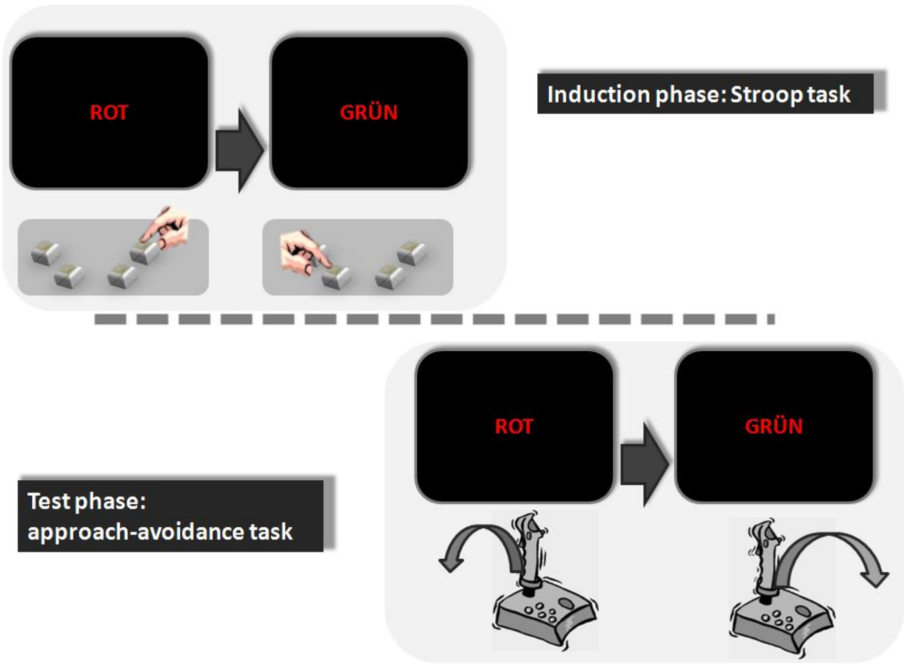

Figure 2 Experimental procedure. Participants first performed a 4 finger Stroop task. During this induction phase stimuli were associated with different level of conflict (upper panel). In a separate subsequent test phase, participants performed an approach-avoidance task. In this task responded to the onset of the Stroop stimuli and no conflict could be solved during this task.

Procedure

Stroop task (Conflict-induction phase). This task was introduced to the participant as a "color sorting task". Participants were instructed to respond to the ink color of a word by pressing the keys ‘a’, ‘f’, ‘l’ or ‘#’ using the index and middle fingers of their left and right hands. The assignment of the response buttons to the ink color was counterbalanced across participants. At the start of a trial, a fixation-cross was presented for 300 milliseconds (ms) followed by a colored word which prompted the participant to respond as quickly as possible. After 1000 ms, a blank screen was presented until registration of a key press. In case of an incorrect or late response (RT >1000 ms), an error message appeared for 1000 ms. The next trial started after an intertrial-interval of 1000 ms. The Stroop task consisted of 3 blocks of 8 congruent and 8 incongruent trials.

AAT (motivation test). This task was described to the participants as a “word sorting task.” Instructions stated that in this task two kinds of words will be shown: one-color words that refer to only one color and two-color words that refer to two different colors. Participants were to indicate whether a one-color word or a two-colored was present by pulling a joystick lever to the body (approach) and by pushing the lever away from the body (avoidance). For additional references to approach and avoidance, the lever movements were linked to visual illusions of word movements towards and away from the participant (“zoom effect”; see Rinck & Becker, 2007). The size of the word increased (by the factor 3.5) after registration of a lever pull and decreased (by the factor 0.1) after registration of a lever push for a duration of 300 ms (with a rate of 33 pictures/second). After 1000 ms, a blank screen was presented until registration of a button press. In case of wrong or late responses (RT >2000 ms) an error message appeared for 1000 ms instead of a “zoom effect”. The next trial started after an intertrial-interval of 1000 ms.

One-color (i.e., congruent) and two-color (i.e., incongruent) words were presented in random order with the constraint that a word type was not repeated more than three times in a row.

The AAT consisted of 24 blocks with 16 trials each (8 one-color, 8 two-color words). The assignment of the responses (approach vs. avoidance) to the words (one-color vs. two-color) changed after 12 blocks (the order of the instructions was counterbalanced across participants). No practice trials were administered to facilitate a transfer from the induction phase to the motivational test. After each block, participants received feedback about the mean reaction times and error rate.

5.1.2 Results

Stroop task

Error rates. Responses to incongruent color words were more error-prone (M = 33.0%; SD = 17.6 %) than responses to congruent color words (M = 17.6%; SD = 16.4%), $t(41) = 6.19$, $p < .001$, $d = 0.94$.

Reaction times. Trials with RTs faster than 100 ms were considered as anticipations (6.8%). Furthermore, trials with erroneous responses (14.7%) and RTs that deviated more than 3 SDs from the corresponding cell mean (0.1%) were excluded from RT analyses. High error rates resulted in empty cells (N < 10) for six participants. Data of these participants were not further analysed. In line with the results of the error analysis, responses to incongruent stimuli took significantly longer (M = 670 ms; SD = 74 ms) than responses to congruent stimuli (M = 609 ms; SD = 67 ms), $t(35) = 6.35$, $p < .001$, $d = 1.05$.

AAT

Trials with premature responses (RT < 100 ms; 2.9%) or response omissions (0.2%) and trials with joystick movements in left and right directions (3.3%) were excluded from the analyses.

Reaction times. Trials with incorrect responses (5.9%) and with RTs that deviated more than 3 SDs from the corresponding cell mean (1.2%) were excluded from the RT analyses. A repeated-measures analysis of variance (ANOVA) with the factors *congruency* (congruent, incongruent) and *response type* (approach, avoidance), yielded a main effect of *congruency*, $F(1, 41) = 38.93$, $p < .001$, $\eta_p^2 = .487$, with faster reactions in congruent trials (M = 679 ms) compared to incongruent trials (M = 709 ms). The main effect of *response type* was also significant, $F(1, 41) = 8.81$, $p = .005$, $\eta_p^2 = .177$. Approach responses were generally executed faster than avoidance movements (*Ms* = 687 ms vs. 702 ms). Most important, the interaction between *congruency* and *response type* was significant, $F(1, 41) = 13.26$, $p < .001$, $\eta_p^2 = .244$. As shown in Figure 3, participants were faster to avoid incongruent (two-color) words (M = 643 ms; SD = 129 ms) than congruent (one-color) words (M = 715 ms; SD = 122 ms), $t(41) = 5.47$, $p < .001$, $d = 0.84$. The speed of approach responses did not differ significantly, $t(41) = 1.58$, $p = .120$.

Error rates. An analogous repeated-measures ANOVA with the factors *congruency* (congruent, incongruent) and *response type* (approach, avoidance), yielded only a significant interaction between *congruency* and *response type*, $F(1, 41) = 32.07$, $p < .001$, $\eta_p^2 = .439$. Follow up t-tests revealed that avoidance responses to incongruent (two-color) words (M = 4.4%; SD = 3.9%) were less error-prone than avoidance responses to congruent (one-color) words (M = 8.1%; SD = 5.6%), $t(41) = 5.05$, $p < .001$, $d = 0.79$. In contrast, errors were more frequent when executing an approach response to incongruent words (M = 8.3%; SD = 5.3%) compared to congruent words (M = 4.6%; SD = 4.2%), $t(41) = 5.49$, $p < .001$, $d = 0.84$.

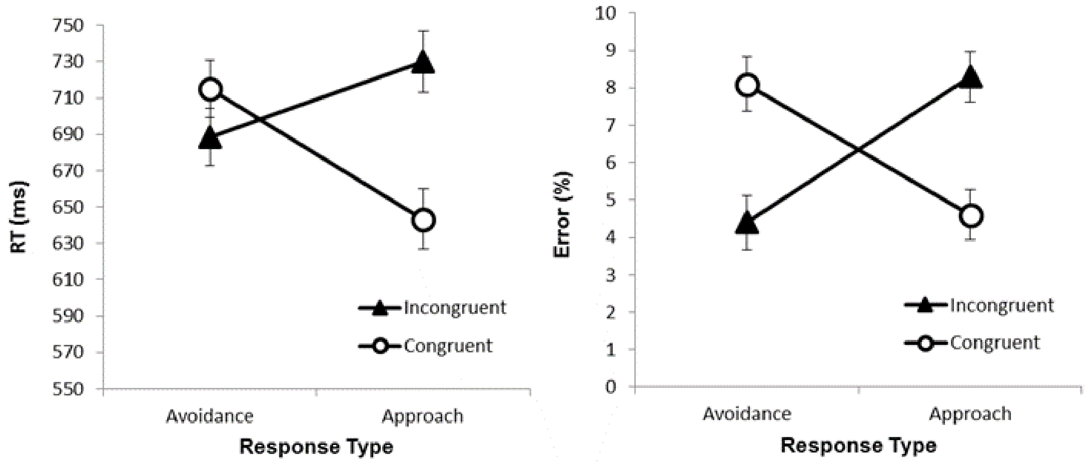

Figure 3 Mean reaction time (RT, left panel) and errors (in percent, right panel) in Experiment 1 as a function of congruency. Error bars show standard errors of paired differences calculated individually for each contrast between response types (Pfister & Janczyk, 2013).

Correlation analyses. To test whether participants who exhibited a strong Stroop effect in the induction phase also show a strong avoidance bias to incongruent words, I calculated for each participant the Stroop effect in the error rates (errors in incongruent trials – errors in congruent trials) for the first phase and an index of the avoidance bias of incongruent words in the test phase [(avoidance response for congruent – avoidance response for incongruent) + (approach response for congruent – approach responses for incongruent)/2] and correlated both indices in a second step. Because high error rates in the Stroop task caused missing RT data for six participants (see above), I considered for a computation of the Stroop effect only error rates as a performance measure. One outlier was excluded due to an unusual strong congruency effect in the Stroop task (66% > 3 SD of the group mean, ΔM = 14.1%)[3]. As can be seen in Figure 2, participants who displayed a stronger congruency effect in the Stroop task

[3] When including the data of this participant the correlation remained significant.

exhibited a stronger avoidance bias to incongruent relative to congruent words in the RT measure (r = .298, p = .029, one-sided) and in the error measure (r = .314, p = .023, one-sided) of the AAT.

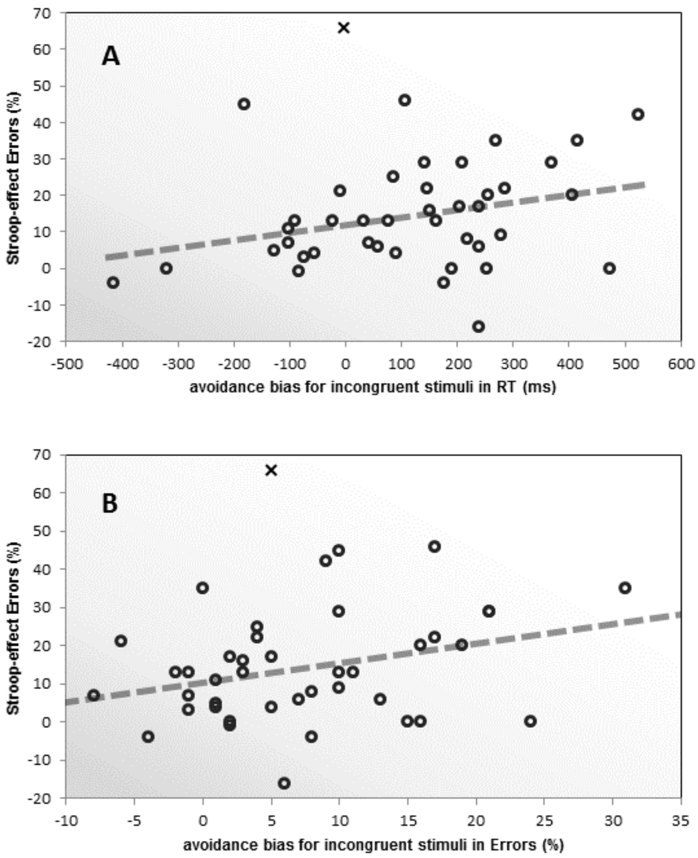

Figure 4 Correlation of the congruency effect (in percent error rates) in the Stroop task and the bias to avoid incongruent stimuli in the approach-avoidance task (for RTs: upper panel; for errors: lower panel). RT/error scores exceeding zero indicate an avoidance bias for incongruent stimuli. Positive difference scores for Errors on the y-axis indicate a stronger congruency effect in the Stroop task. One outlier is marked.

5.1.3 Discussion

Based on the conflict management framework it was hypothesized that the conflict-inducing stimuli triggered a tendency to withdrawal from the source of conflict, which results in a motivational bias to avoid these stimuli. In line with this theorizing, formerly incongruent Stroop displays (two-color words) facilitated avoidance responses relative to approach responses, suggesting that these stimuli induced an avoidance motivation. Furthermore, correlational analyses showed that the Stroop effect was systematically related to the size of the avoidance bias, providing further evidence for a relationship between conflict and aversive motivation.

One potential caveat against this interpretation concerns the labels of the stimulus categories that were instructed for the AAT in Experiment 1. Although these neutral category labels were carefully selected (one-color and two-color words) for this task, it cannot be ruled out that the labels of the stimulus categories carried an affective connotation that was independent of the conflict-inducing properties. Accordingly, it is possible that the results could be alternatively explained with a compatibility relation between affective stimulus labels and approach-avoidance responses (Eder & Rothermund, 2008). To rule out this potential confound, no stimulus labels were instructed for the AAT in Experiment 2. Instead, participants had a free choice between approach and avoidance response when a color-word was presented on the screen.

5.2 Experiment 2

Experiment 2 presented the same Stroop task as Experiment 1. The motivation test was however a free-choice test and not a forced-choice AAT. Participants should execute either an approach- or an avoidance-related lever movement when a color word appeared on the screen (go-trial) and should perform no response when no word appeared on the screen (no-go trial). No-go trials were included to minimize response strategies prior to stimulus presentation. In the go trials, participants had a free choice between executing an approach-related response or an avoidance-related response. With this procedure, it is possible to investigate approach and avoidance tendencies without instructing stimulus categories in a categorization task.

In line with the conflict management framework I expected that the stimulus type (incongruent vs. congruent) biases the choice between avoidance and approach responses. More precisely, an avoidance response should be selected more frequently after presentations of incongruent color words, while approach responses should be selected more frequently following the presentation of a congruent color word. Again, correlational analyses were performed to examine whether the magnitude of Stroop-conflict exhibited in the first phase of the experiment is predictive of an avoidance bias in the second phase.

5.2.1 Method

Participants

Fifty-two students at the University of Würzburg were paid for participation (39 women, 4 left-handed, 18–54 years). Participants were naive to the purpose of the experiment. Data of one participant were removed due to an unusual high error rate in the go/no-go task (20%, > 3 SDs of the group mean M = 1.3%).

Stimuli

Color words were the same as in Experiment 1. No-Go stimuli in the test phase were the letters “XXXX” printed in grey color (Calibri) that subtended 21.36° (width) x 5.87° (height) of visual angle measured from a viewing distance of 50 cm.

Procedure

The conflict-induction phase (Stroop task) was identical to Experiment 1.

AAT (motivation test phase). A white fixation-cross was presented for 300 ms at the start of a trial followed by either a color word which prompted the participant to respond with a lever movement (Go-trial) or a string of X which prompted the participant to refrain from a response (No-Go trial). Lever movements with zooming effects were the same as in Experiment 1. Upon onset of a color word, participants were instructed to choose freely on each trial which of the two lever responses (push vs. pull) they want to perform. However, instructions also stated that both movement types should be performed about equally often in a block and that they should avoid using response strategies like single or alternating responses in a fixed sequence (for a similar procedure see Dignath, Pfister, Eder, Kiesel, & Kunde, 2014; Elsner & Hommel, 2001). A counter at the end of the block informed about the response proportion. Furthermore, an error message appeared for 1000 ms in case of responses in No-Go trials or late response (RT > 2000 ms). The next trial started after an intertrial-interval of 1000 ms. Congruent, incongruent and no-go stimuli were presented in random order with the constraints that a stimulus type was not presented more than three times in a sequence. The

Stroop task consisted of 20 blocks with 8 go trials (4 congruent and 4 incongruent color words) and 8 no-go trials each.

5.2.2 Results

Stroop task

Error rates. Like in Experiment 1, errors were more frequent in incongruent trials (M = 30.3%; SD = 20.5%) than in congruent trials (M = 16.8%; SD = 13.8%), $t(50) = 6.64$ $p < .001$, $d = 0.93$.

Reaction times. Trials with RTs faster than 100ms were considered as anticipations (6.4%) and excluded. Furthermore, trials with erroneous responses (13.0%) and RTs that deviated more than 3 SDs from the corresponding cell mean (0.2%) were removed from RT analyses. High error rates resulted in empty cells (N < 10) for five participants that were removed from analyses. As expected, responses to incongruent color words were slower (M = 671 ms; SD = 88 ms) than responses to congruent stimuli (M = 610 ms; SD = 88 ms), $t(45) = 7.67$, $p < .001$, $d = 1.05$, corroborating the results of the error analysis.

AAT

Trials with response anticipations (< 100 ms; 0.1%) or response omissions (0.4%) and trials with joystick movements to the left or right (2.3%) were removed from analyses.

Response Choice. As shown in Figure 5, participants selected approach movements more often as a response to congruent color words (M = 53.9%; SD = 13.9%) than avoidance movements, $t(50) = 2.04$, $p = .046$, $d = 0.28$. In response to incongruent color words, in contrast, avoidance responses were selected more often (M = 55.0%; SD = 11.4%) than approach responses, $t(50) = 3.12$, $p = .003$, $d = 0.44$.

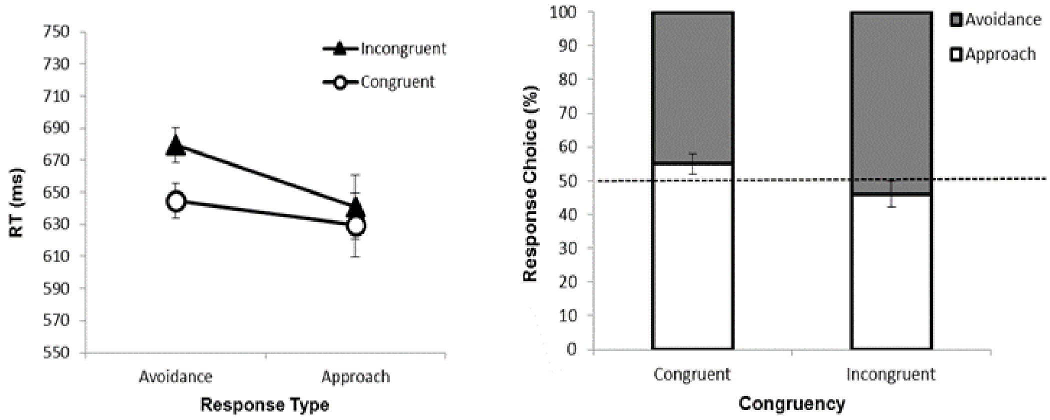

Figure 5 Mean reaction time (RT, left panel) and choice frequencies (in percent, right panel) in Experiment 2 as a function of congruency. Error bars show standard errors of paired differences calculated individually for each contrast between response types (Pfister & Janczyk, 2013).

Reaction times. Trials with RTs that deviated more than 3 SDs from the corresponding cell mean (0.6%) were excluded from the RT analysis. High error rates resulted in empty cells (N < 10) for one participant; these data were dropped from analysis. A repeated-measures ANOVA with the factors *congruency* (congruent, incongruent) and *response type* (approach, avoidance), yielded a main effect of *stimulus congruency*, $F(1, 49) = 11.07$, $p = .002$, $\eta_p^2 = .184$, with faster reactions for congruent words ($M = 637$ ms) compared to incongruent words ($M = 660$ ms). The main effect of *response type* was significant, $F(1, 49) = 15.38$, $p < .001$, $\eta_p^2 = .239$. Responses were faster for approach movements ($M = 635$ ms) compared to avoidance movements ($M = 662$ ms). The interaction between *stimulus congruency* and *movement type* did not reached significance, $F(1, 49) = 2.04$, $p = .160$.

Correlation analyses. Like for Experiment 1, a Stroop effect was computed for the first phase, an avoidance bias to incongruent stimuli for the second phase. Because high error rates in the Stroop task caused missing data for some participants, only error rates were used for the calculation of the Stroop effect. As can be seen in Figure 6, participants who displayed a stronger congruency effect in the Stroop task exhibited also a stronger bias to avoid incongruent color words, $r = .337$, $p = .008$ (one-sided).

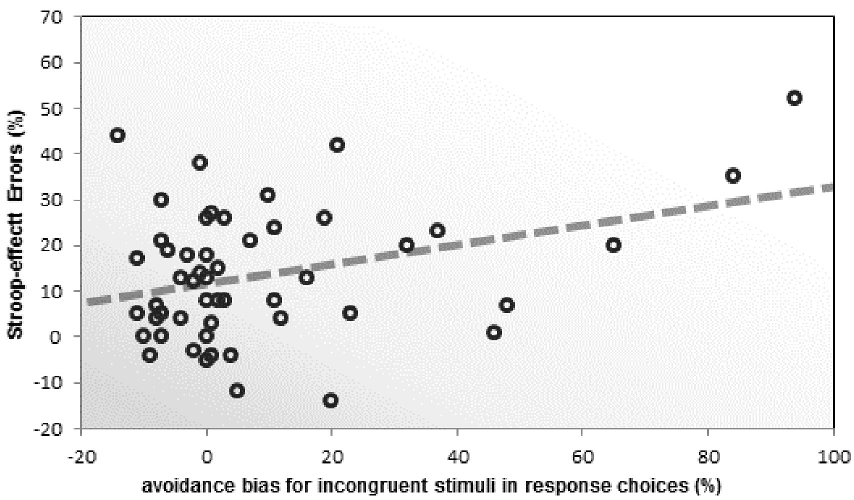

Figure 6 Correlation of the congruency effect (in percent error rates) in the Stroop task and the bias to avoid incongruent stimuli in the free choice approach-avoidance task. Percentage response choices exceeding zero indicate an avoidance bias for incongruent stimuli. Positive difference scores for errors on the y-axis indicate a stronger congruency effect in the Stroop task.

5.2.3 Discussion

Results reproduced the findings of Experiment 1 using a free-choice AAT. When participants had to decide whether they want to perform an approach or avoidance response, they preferred avoidance responses in the presence of incongruent color words and approach response in the presence of congruent stimuli. This pattern and the finding of a positive correlation between the Stroop effect and the magnitude of avoidance bias in the AAT, provide additional support for the current theorizing that stimuli associated with conflict trigger withdrawal from conflict. Furthermore, the use of a go/no-go task in Experiment 2 rules out an alternative explanation of the motivational AAT effect in terms of an match between affective connotations of instructed category labels and responses independent of conflict. Instead, these results suggest that stimuli motivate withdrawal when they have caused conflict in the past.

5.3 Discussion of Experimental Series A

The present findings provide evidence that conflict triggers a conflict-withdrawal tendency from the source of conflict. This is initial evidence for a reactive accommodation strategy, supporting the conflict management framework. Furthermore the present results are consistent with the notion that the detection of a conflict causes a negative evaluation of the conflict-inducing situation (Dreisbach & Fischer, 2012). Furthermore the conflict signal triggers a reactive withdrawal tendency from the source of conflict, providing evidence for the reactive avoidance strategy.

Finally, the results fit well with previous research that documented the influence of motivation on the resolution of conflict. For instance, monetary incentives have been found to reduce conflict by enhanced cognitive control for a wide range of domains like task switching, working memory, anti-saccade tasks and response interference tasks (Chiew & Braver, 2014; Harsay et al., 2011; Locke & Braver, 2008; Padmala & Pessoa, 2011; Savine, Beck, Edwards, Chiew, & Braver, 2010). Recently, Schouppe, De Houwer, Richard Ridderinkhof and Notebaert (2012) reported a reduction in the Stroop effect when participants moved a virtual manikin away from a color word. In line with the present results the authors suggested that “when [participants are] confronted with conflict, avoiding is the predominate response” (Schouppe et al., 2012, p. 1057). Now, this interpretation of their data hinges on the critical assumption that conflict influenced the execution of approach/avoidance movements. However, an alternative interpretation would be that anticipating/planning the execution of a specific response type (e.g. avoidance) influenced cognitive control, giving rise to a reduced Stroop effect. Indeed, Koch, Holland and van Knippenberg (2008) reported evidence that avoidance movements facilitated cognitive control in the Stroop task. Approach-avoidance behavior was manipulated between participants by inducing arm flexion or extension. Participants in the avoidance condition showed a reduced Stroop effect compared to participants in the approach condition.

Experiment 1 and 2 go beyond existing research by disentangling the resolution of conflict in the Stroop task form the assessment of motivation in the AAT and thereby provide univocal evidence for the influence of conflict on motivation. Arguably, the motivational avoidance tendency away from conflict comprises a mean to withdraw from conflict. This interpretation is supported by correlation analysis revealing that participants who experienced a stronger conflict in the Stroop task showed a stronger bias to avoid conflict associated words in the subsequent motivation test. Further research is necessary to test whether this correlation is caused by (i) individual differences in the ability to acquire or to recall the association between conflict and stimuli or by (ii) individual differences in the sensitivity to conflict.

The following chapter is based on:

Dignath, D., Kiesel, A. & Eder, A. (under review). Conflict Avoidance and Conflict Adjustment in Reactive Cognitive Control.

Chapter 6

Experimental Series B – Adjust and Withdrawal

Results of Experiment 1 and 2 showed first evidence of a reactive accommodative strategy. The present series of experiments approached the reactive accommodative strategy from a decision-making perspective. I reasoned that when participants have to decide between two conflict tasks, a reactive accommodative strategy would bias decision making away from the source of conflict (the task that was in the previous trial associated with conflict). To probe a reactive accommodation strategy in decision-making, participants could freely select which of two distinct response interference tasks they wanted to perform on each trial. Analyzing task choices as a function of conflict in the previous trial provide an intuitive metric of withdrawal from conflict. Thus, it was expected that participants should switch away from a task after experiencing a conflict, even though both tasks had an equal probability of conflict. Please note that this effect cannot be explained with a proactive accommodation strategy, because learning is not possible in the present paradigm and withdrawal from conflict must proceed in a trial-by-trial fashion.

Furthermore, trial-to-trial variations (Gratton effects) in task performance provide a metric for a adjustment to conflict. Thus, Experimental series B tested the jointly implementation of reactive assimilation and reactive accommodation. For a test of both reactive conflict management strategies, an experimental setup is required that allows participants to apply both strategies simultaneously. This was not the case in previous studies examining one strategy or the other. For example, conflict adjustment is typically investigated with response interference tasks that examine variations in performance. Thus, avoidance of conflict is not possible in these paradigms. On the other hand, conflict avoidance is typically investigated with tasks in which participants can choose between two tasks that are associated with different levels of conflict. Those setups measure the effect of conflict on task choice as a function of conflict probability (e.g., conflict avoidance); however, adjustment to conflict was not investigated with these paradigms.

To allow participants to apply both conflict-management strategies, two response-interference tasks were combined with a variation of the voluntary task switching (VTS) paradigm (Arrington & Logan, 2004, 2005). In a standard VTS paradigm, participants view a series of bivalent stimuli and decide on each trial which of two available tasks they want to perform on a target stimulus. Participants are free to select the task to perform, but are instructed to avoid predictable pattern of choices and to choose both task approximately equal numbers of times. In the VTS paradigm, task choice is measured in addition to performance-related variables (RTs, error rates). A typical finding is a strong bias to repeat a previously selected task (Arrington & Logan, 2004, 2005; Vandierendonck, Liefooghe, & Verbruggen, 2010).

Orr, Carp and Weissman (2012) have used a VTS paradigm in combination with two conflict tasks. In their experiment, a small digit (e.g., 1) and a large digit (e.g., 9) were presented simultaneously on an upper and a lower position on the screen. One of the digits was shown in a small font and the other in a large font, creating incongruent (i.e., small digits in large font; large digits in small font) and congruent stimulus displays (i.e., small digits in small font; large digits in large font). Participants were to indicate whether the top or the bottom digit is larger by responding to either the numerical size or to the font size of the digits. Importantly, the decision was free in each trial whether they want to perform the magnitude task or the size task. The experimental design of Orr et al. (2012) allows for a simultaneous test of both conflict strategies. However, the results provided evidence for the conflict adjustment strategy only. A Gratton effect was observed in the reaction times, suggesting that participants invested more effort in a task following a conflict trial. Contrary to the assumption of an avoidance strategy, participants repeated the same task more often after a conflict trial than after a non-conflict trial. The authors interpreted the latter finding as further evidence for conflict adjustment, which affects not only performance-related measures but also task choice.

However, characteristics of the stimulus material used by Orr and colleagues (2012) can explain why results did not show avoidance after conflict[4]. Consider a conflict trial in which the magnitude task is performed on an incongruent stimulus pair (e.g. the digit “3” in large font and the digit “7” in small font). Such a *bivalent* stimulus affords both the magnitude and the size task at the same time. For a resolution of conflict, the representation of the numerical size must be strengthened and the representation of the font size must be weakened.

[4] It should be noted that the study by Orr et al. was not meant as a test for both conflict strategies, but was designed as an exclusive test of an adjustment strategy (conflict monitoring account).

Consequently, the likelihood that the now-dominant magnitude task is repeated in a subsequent trial is increased, while the likelihood for a switch to the now-inhibited size task is decreased. The mutual influence of task representations in bivalent tasks (i.e., between-task interference) can explain the tendency to repeat tasks after a conflict trial. Participants could not avoid conflict because bivalent stimuli entailed relevant attributes for both tasks.

As set out above, the present series of experiments is intended to provide empirical evidence for the simultaneous implementation of two different control strategies. Participants switched voluntarily between two univalent response-interference tasks. I measured task choice (switch rates) as an index of conflict avoidance. Performance-related measures (RT, error rate) indexed conflict adjustment. To anticipate the results, conflict adjustment in performance measures and conflict avoidance in choice rates were jointly observed with this paradigm (Experiment 3). Experiment 4 presented bivalent instead of univalent stimuli, reproducing the experimental condition of Orr et al. (2012). Adjustment to conflict found in performance measures was not affected by this manipulation but critically choice rates revealed a tendency to repeat tasks following conflict, reproducing the finding of Orr and colleagues. Experiment 5 tested directly the prediction that task switch rates following conflict are reduced for bivalent stimulus sets, while switch rates after conflict are increased for univalent stimuli. In this experiment, participant could select between a task with univalent stimuli and a task with bivalent stimuli. As expected, conflict avoidance in choice rates was found for the task with univalent stimuli but not for the task with bivalent stimuli. Conflict adjustment in performance measures (RTs, errors) was robust irrespective of the use of univalent and bivalent stimuli.

6.1 Experiment 3

Experiment 3 probed a reactive accommodation and reactive assimilation strategy jointly. In each trial, participants freely choose between a Flanker task (Eriksen & Eriksen, 1974) and a Simon task (Simon, 1969). Similarly to the Stroop task, selection of a correct response to a target conflicts with automatic response tendencies instigated by an irrelevant task feature. Participants responded in the Flanker task to the identity of a centrally presented target letter that was flanked by distractor letters. In the Simon task, digits were presented to the left and right side of the computer screen that were categorized as smaller or greater than five. Responses are typically faster and less error-prone in these tasks when the irrelevant feature affords the same response as the target (congruent trials) compared to when they afford different responses (incongruent trials), producing a congruency effect (Kornblum, Hasbroucq, & Osman, 1990).

Both categorization tasks involved presentations of univalent stimuli. More precisely, task-relevant stimulus dimensions (i.e., letter identity for the Flanker task and numerical size for the Simon task) and task-irrelevant stimulus dimensions (i.e., Flanker stimulus for the Flanker task and spatial location for the Simon task) were clearly distinct and did not overlap across tasks.

Task choice (switch rates) was used as an index of withdrawal from conflict. If participants respond with an reactive accommodation strategy, task switches should be more frequent after (incongruent) conflict trials relative to (congruent) non-conflict trials. Task performance (RT, error rate) was used as index for conflict adjustment to overcome conflict. If participants use a reactice assimilation strategy, a Gratton effect should be observed.

6.1.1 Method

Participants

Thirty-eight participants (32 women, 18–42 years) were paid for participation. Exclusion criteria were the same for all reported experiments. Data from participants were removed from analyses when the number of task switches in the voluntary task switching procedures was too high or too low (proportion of task repetitions < 5% or > 95%). One participant in Experiment 1 was excluded due to this criterion. Furthermore, data sets from participants were excluded who produced extremely long series of task repetitions and/or task switches that resulted in empty cells for some conditions. Two participants in Experiment 1 were excluded due to this criterion. Finally, participants with extremely high error rates (> 3 SDs) were excluded. This criterion led to a removal of two participants in Experiment 1.

Stimuli

The letters H and S served as targets (presented at a central position) and as flanker stimuli (presented at lateral positions) for the Flanker task. Digit numbers were categorized as smaller (digits 1-4) and larger (digits 6-9) than 5 in the Simon task. The digit appeared on the left or right side of fixation on the computer screen.

Procedure

After 50 practice trials of each task (counterbalanced task order), participants were informed that they can now choose freely which of the two tasks they want to perform in a given trial. However, it was also stated that they should select each task about equally often without using a strategy (for a similar procedure see Arrington & Logan, 2004). A double-registration procedure was used (Arrington & Logan, 2005, Experiment 6; Orr et al., 2012). More precisely, participants indicated their task choice by pressing the keys ‘a’ and ‘f’ using the index and middle fingers of their left hand. Participants performed the interference tasks using the index and middle finger of their right hand by pressing the ‘l’ and ‘#’ keys that were marked with green color patches. The task to key mapping and the stimulus to key mapping in both tasks were counterbalanced across participants.

Figure 7 shows the sequence of events in an experimental trial. A question mark was presented on the screen until a task was selected with a corresponding key press. Then a fixation cross appeared for 500 ms followed by a Flanker or a Simon display. After 600 ms, a blank screen was presented until response registration. In case of anticipated (RT < 100 ms), incorrect, or late response (RT >1000 ms) an error message appeared for 1000 ms. The next trial started after a variable intertrial interval of either 100 or 1000 ms. The experiment consisted of 10 blocks of 50 trials. After each block, participants received feedback about the proportion of task choices.

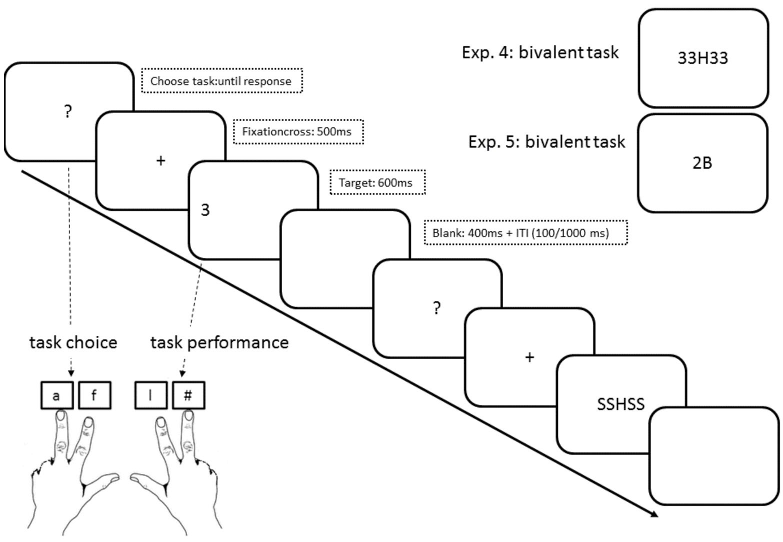

Figure 7. Trial sequence in Experiment 3 with univalent tasks. Examples for bivalent stimuli in Experiment 4and 5 are depicted in the upper right corner.

6.1.2 Results

Task Choice

Switch Rates. In line with the task instructions, both tasks were selected about equally often (Simon task: M = 49.2%; Flanker task: M = 50.8%), $t(32) = 1.65$, $p = .113$). The mean switch rate was 33.6%. This result is in line with previous VTS studies that observed an analogous bias to repeat a previously performed task (see e.g., Arrington & Logan, 2004).

The first trial in each block was not analyzed. Trials with erroneous responses (10.5%) and post-error trials (8.7%) were discarded from the switch-rate analyses. Following the analyses of Orr et al. (2012), a repeated-measures analysis of variance (ANOVA) with the factors *previous congruency* (congruent, incongruent), *previous task transition* (repeat, switch), and *previous task* (Simon, Flanker) was used to analyze the switch rates. This analysis revealed a main effect of *previous congruency*. Participants switched tasks after an incongruent trial (M = 33.3% switches) more often than after a congruent trial (M = 30.9% switches), $F(1, 32) = 5.16$, $p = .030$, $\eta_p^2 = .139$. This effect in the switch rates is in line with a tendency to withdraw from conflict. This effect was further qualified by an interaction with *previous task transition*, $F(1, 32) = 9.15$, $p = .005$, $\eta_p^2 = .223$. Participants switched tasks more often after incongruent compared to congruent trials when the previous trial involved a task alternation, $t(32) = 3.01$, $p = .005$, relative to conditions in which the previous trial involved a task repetition, $t(32) = -.57$, $p = .569$ (see Figure 8).

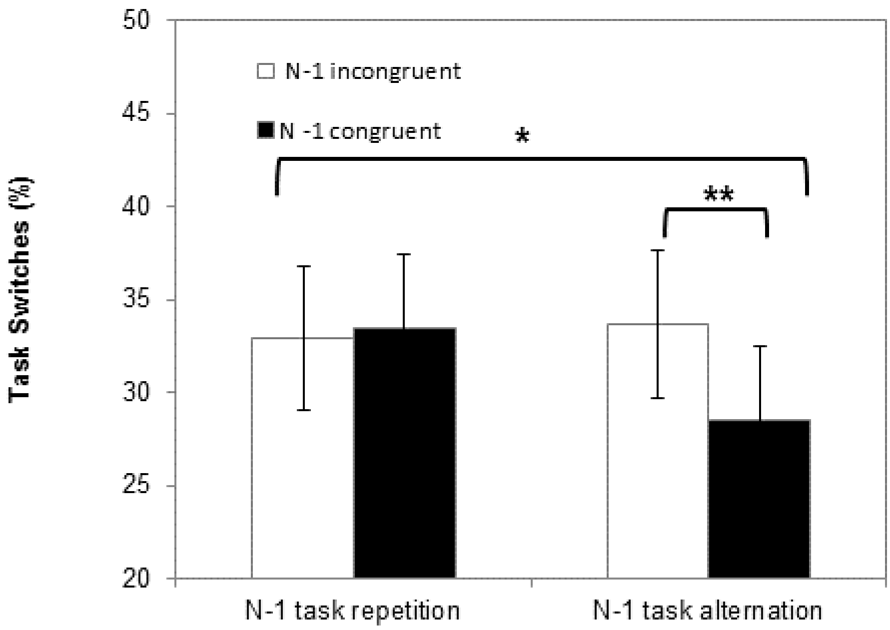

Figure 8. Switch rates in Experiment 3 (univalent stimuli) as a function of congruency in the previous trial (N-1). Error bars indicate the standard error of the mean.

† p < .05 (one-sided).*p < .05. **p < .01. ***p < .001.

Task Performance

Reaction Times. Similar to the task choice analyses, the first trial of each block, error trials and post-error trials were not analyzed. In addition, RTs were removed that exceeded more than 3 SDs from the cell mean for each condition (0.3%). A repeated-measures ANOVA with the factors *previous congruency* (congruent, incongruent), *current congruency* (congruent, incongruent) and *current task* (Simon, Flanker)[5], yielded a significant main effect of *current*

[5] In contrast to Orr et al. (2012), the factors RCI and current task transition were not included the in the present analysis. Exploratory analysis showed that RCI did not interact with any effect of interest in the experiments. Including this factor resulted in empty cells for some conditions, leaving a much smaller dataset for analyses. The same applies to current task transition. After including this factor (leaving an appropriate data set of N = 22) typical switch costs were observed. Critically, none of these factors influenced adjustment-effects in the performance data or withdrawal-effects in the switch rates.

congruency, $F(1, 32) = 121.95$, $p < .001$, $\eta_p^2 = .792$. Responses were faster in congruent trials ($M = 497$ ms) compared to incongruent trials ($M = 523$ ms). The main effect of *current task* was also significant, $F(1, 32) = 208.44$, $p < .001$, $\eta_p^2 = .792$. Responses were faster in Flanker trials ($M = 474$ ms) compared to Simon trials ($M = 546$ ms). The interaction between *current task* and *current congruency* was significant, $F(1, 32) = 44.96$, $p < .001$, $\eta_p^2 = .584$. The congruency effect was stronger in the Flanker task than in the Simon task. More important, a Gratton effect was observed as indexed by a significant interaction between *previous congruency* and *current congruency*, $F(1, 32) = 22.77$, $p < .001$, $\eta_p^2 = .416$ (see Table 1). The congruency effect was reduced after a previous incongruent trial compared to a previous congruent trial. This Gratton effect indicates an adjustment to conflict.

Error Rates. The first trial of each block and post-error trials were not analyzed. An analogous ANOVA of the error rates revealed a main effect of *current congruency*, $F(1, 32) = 28.61$, $p < .001$, $\eta_p^2 = .472$, showing that participants made fewer errors in congruent trials ($M = 7.7\%$) compared to incongruent trials ($M = 11.4\%$). The main effect of *current task* was also significant, $F(1, 32) = 13.83$, $p < .001$, $\eta_p^2 = .302$. Participants made fewer errors in Flanker trials ($M = 8.4\%$) compared to Simon trials ($M = 10.7\%$).

The Gratton effect, indicated by the interaction between *previous congruency* and *current congruency* was significant, $F(1, 32) = 17.22$, $p <.001$, $\eta_p^2 = .350$. This interaction was further qualified by a three-way interaction between *previous congruency* and *current congruency* and *current task*, $F(1, 32) = 6.28$, $p = .017$, $\eta_p^2 = .164$. The Gratton effect was stronger for the Simon task compared to the Flanker task.

Table 2 Means of reaction times (in ms) and error rates (in %) in each experiment as a function of congruency in the previous trial and congruency in the present trial. Standard deviations are shown in parentheses. Gratton effects were computed by subtracting congruency effects following incongruent trials from congruency effect following congruent trials.

	Experiment 1		Experiment 2		Experiment 3	
Trial Type	RT	Error rate	RT	Error rate	RT	Error rate
Incongruent trial following an incongruent trial (iI)	521 (11)	10.2(0.7)	515 (7)	13.7 (0.1)	543 (7)	10.3 (0.7)
Congruent trial following an incongruent trial (iC)	502 (10)	8.4(0.7)	515 (7)	10.6 (0.1)	538 (7)	9.5 (0.7)
Incongruent trial following a congruent trial (cI)	525 (9)	12.6(0.9)	518 (7)	15.0 (0.1)	547 (7)	11.3 (0.8)
Congruent trial following a congruent trial (cC)	491 (10)	7.0(0.7)	512 (7)	10.9 (0.1)	529 (7)	8.0 (0.6)
Gratton effect: (cI-cC) –(iI)-(iC)	15***	3.7***	6*	0.9	13***	2.4**

† $p < .01$.*$p < .05$. **$p < .01$. ***$p < .001$.

6.1.3 Discussion

Experiment 3 provided clear evidence that people can adjust to and withdraw from conflict situations simultaneously in one task, suggesting some flexibility in the management of conflict situations. A Gratton effect was observed for task performance (RTs and error rates), indicating reactive adjustment to conflict. In addition, for task choices more switches after a conflict trial in task alternation trials were observed, indicating reactive withdrawal from conflict.

Interestingly, withdrawal from conflict was particularly strong after a previous task alternation. Task-set priming (“autogenous priming“) can account for this effect (Monsell, Sumner, & Waters, 2003). Task-set priming occurs from repeating the same task in succession. For instance, Ruthruff, Remington and Johnston (2001, see also Sumner & Ahmed, 2006) observed increased switch costs in a series of task repetitions. Thus, task repetitions may have increased the activation level of the repeated task. This enhanced activation of a repeated task may then have overshadowed the tendency to switch to another task following a conflict trial. This overshadowing is however absent after task alternations, explaining withdrawal from conflict in this condition (see sections 6.3 and 9.2 for a more thorough treatment of this point).

6.2 Experiment 4

The goal of Experiment 4 was to test the assumption that conflict withdrawal can only be observed with tasks that use univalent stimuli, but not with tasks that use bivalent stimuli (Orr et al., 2012). As outlined in the introduction of this chapter, bivalent stimuli afford responses for both tasks and thus cause between task interference. Experiment 4 used similar procedures as Experiment 3 with the major change that a bivalent stimulus set was used in this study. In each trial, a digit *and* a letter appeared centrally on the computer screen (cf. Rogers & Monsell, 1995). Participants could freely decide whether they wanted to perform the letter task or the digit task. In the letter task, participants were to categorize the letter as one of the first four letters of the alphabet by pressing one button or as one of the last 4 letters of the alphabet by pressing the other button. In the digit task, participants were to categorize the numbers as less or greater than five. Thus, the stimuli were bivalent in respect to both categorization tasks.

Experiment 3, this experiment assessed the Gratton effect in task performance (RT and error rates) as an index for conflict adjustment. However, as shown by Orr and colleges (2012) bivalent stimuli impede possible withdrawal from conflict. Instead, participants should stay with the previous active task after conflict; hence, switch rates should be lower after a conflict trial compared to a non-conflict trial.

6.2.1 Method

Participants

Fifty participants (39 women, 18–54 years) were paid for participation. Data from nine participants was excluded because of an inadequate number of task switches and five participants due to an extremely long series of task repetitions and/or task switches.

Stimuli and Procedure

Experiment 4 resembles Experiment 3 except for the following changes. The letters A, B, C, D and V, W, X, Y served as targets for the letter task. The digits 1-4 and 6-9 were targets for the digit task. Letters and digits were printed in white. In each trial one letter and one digit was presented at a central position next to each other.

6.2.2 Results

Task Choice

Switch Rates. Both tasks were selected about equally often (Simon task: M = 50.4%; Flanker task: M = 49.6%), $|t| < 1$. The mean switch rate was 27.4%.

The first trial in each block was not analyzed. Trials with erroneous responses (13.1%). and post-error trials (10.6%) were discarded from the analyses. An ANOVA with the factors *previous congruency* (congruent, incongruent), *previous task transition* (repeat, switch), and *previous task* (Letter, Number) revealed more frequent task switches after an congruent trial (M = 30.6% switches) than after an incongruent trial (M = 28.8% switches), $F(1, 35) = 4.36$, p = .044, η_p^2 = .111. No other effects reached significance.

Task Performance

Reaction Times. Similar to the task choice analyses, the first trial of each block, error trials and post-error trials were not analyzed In addition, RTs were removed that exceeded more than 3 SDs from the mean (0.9%).An ANOVA with the factors *previous congruency* (congruent, incongruent), *current congruency* (congruent, incongruent) and *current task* (letter, number) yielded a significant main effect of *current task*, $F(1, 35) = 5.77$, p = .022, η_p^2 = .142. Responses were faster in the digit task (M = 512 ms) compared to the letter task (M = 518 ms). A Gratton effect was observed as indexed by a significant interaction between *previous congruency* and *current congruency*, $F(1, 35) = 4.22$, p = .047, η_p^2 = .108. Surprisingly, the main effect for *current* *congruency* was not significant. Follow-up tests revealed that this was due to the Gratton effect. After previous compatible trials the difference between congruent trials (M = 512 ms) and incongruent trials (518 ms) was significant, $t(35) = 2.92$, $p = .006$, but not after previous incompatible trials $|t| < 1$ (see Table 2).

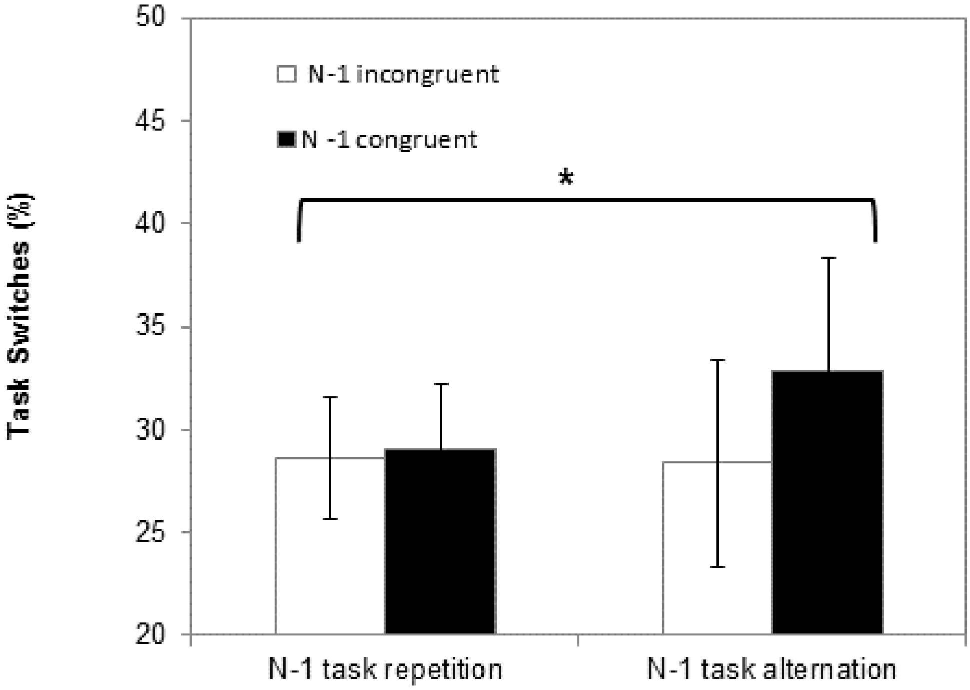

Figure 9. Switch rates in Experiment 4 (bivalent stimuli) as a function of congruency in the previous trial (N-1). Error bars indicate the standard error of the mean.

† p < .05 (one-sided).*p < .05. **p < .01. ***p < .001.

Error Rates. The first trial of each block and post-error trials were not analyzed. An analogous ANOVA of the error rates revealed only a main effect of *current congruency*, $F(1, 35) = 21.69$,

$p < .001$, $\eta_p^2 = .383$. Participants made fewer errors in congruent trials (*M* = 10.7%) compared to incongruent trials (*M* = 14.4%). All other effects were not significant

6.2.3 Discussion

In Experiment 4, conflict adjustment was indexed by a Gratton effect. However, withdrawal from conflict was not observed when tasks consisted of bivalent stimuli. Instead, reproducing the findings of Orr et al. (2012) participants switched tasks more frequently after non-conflict trials. Arguably, this effect is due to between task interference. Bivalent stimuli afford responses for both tasks. To resolve between task interference, the representation of the currently relevant task must be strengthened and the representation of the currently irrelevant task must be weakened. As a consequence a switch to this task is less likely.

6.3 Experiment 5

Experiment 5 tested more directly the assumption that withdrawal from conflict is reflected in switch rates for univalent stimuli but not for bivalent stimuli. The Flanker task of Experiment 3 was modified in a way that the task involved presentations of bivalent stimuli. In Experiment 5, the distracter stimuli surrounding the target (“S” or “H”) in the Flanker task were digit numbers that were also used as targets in the (univalent) Simon task. Thus, the stimulus displays were bivalent for the flanker task and univalent for the Simon task. It was hypothesized that a conflict in the bivalent Flanker task is solved by weakening the (irrelevant) number representation and thus should affect both tasks. In contrast, conflict in the univalent Simon task is solved by weakening the representation of the (irrelevant) location. Overcoming this conflict should not affect the alternative flanker task. Hence, participants should show increased switch rates after conflict compared to non-conflict trials after performing the univalent Simon task but a reversed pattern for the bivalent Flanker task. Statistically this should become apparent in a three-way interaction for switch rates between *previous congruency*, *previous task*, and *previous switch*.

6.3.1 Method

Participants

Sixty students (43 women, 19-36 years) were paid for their participation. Data from nine participants was excluded because of a failure to produce an adequate number of task switches in the voluntary task switching procedures (proportion of task repetitions below 5% or above 95%). Furthermore, data from three participants was excluded who showed extremely long series of task repetitions and/or task switches that resulted in empty cells for some conditions. In addition, data of four participants had to be excluded due to an error of the experimenter who labeled the response keys incorrectly.

Stimuli and Procedure

Experiment 5 was identical to Experiment 3 with the single exception that flanker stimuli were now the numbers 1-4 and 6-9. These digits also served as targets in the Simon task.

Congruency in the bivalent Flanker task was defined in respect to the responses to the digits in the Simon task.

6.3.2 Results

Task Choice

Switch rate. Participants chose the bivalent Flanker task and the univalent Simon task about equally often (Simon task: 49.9%, $|t| < 1$). Like in Experiments 1 and 2, there was a tendency to repeat the previously performed task (mean switch rate: 35.1%).

The first trial in each block was removed from the analyses. Trials with erroneous responses (10.4%) and post-error trials (8.1%) were discarded from the switch-rate analyses. An ANOVA with the factors *previous congruency* (congruent, incongruent), *previous task transition* (repeat, switch), and *previous task* (univalent Simon task, bivalent Flanker task) revealed only a significant three-way interaction, $F(1, 43) = 5.07$, $p = .029$, $\eta_p^2 = .106$. As expected, task switches after a previous incongruent trial were more frequent after performing the univalent Simon task but not after performing the bivalent Flanker task (see Figure 11). Like in Experiment 3, the conflict-withdrawal effect in the univalent Simon task was restricted to trial sequences with previous task alternations: After a previous task alternation, participants working on the univalent Simon task switched more frequently to the bivalent Flanker task following incongruent ($M = 36.7$ %) relative to congruent Simon trials ($M = 33.7$ %) $t(43) = 1.83$, $p = .036$ (one-tailed), while no difference was observed after previous task repetitions. Congruency in the bivalent Flanker task had no effect on switch rates (all *p*s > .41).

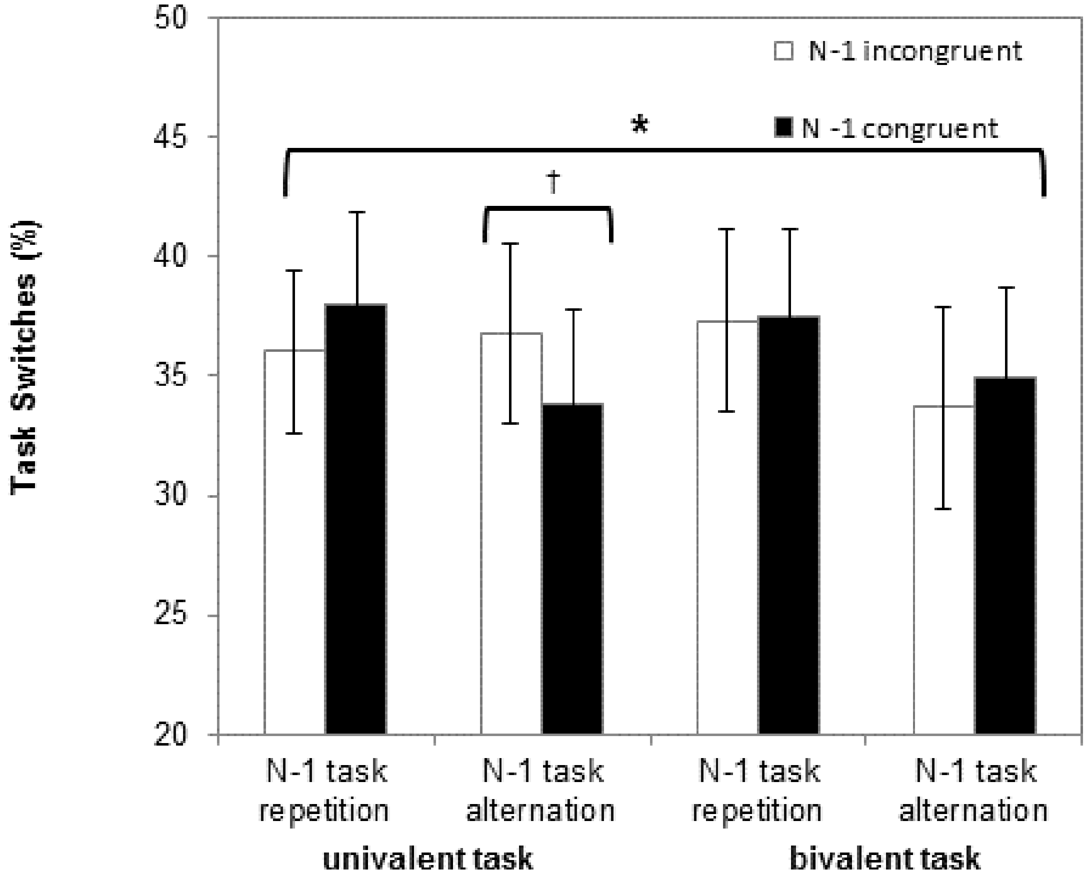

Figure 11. Switch rates in Experiment 5 as a function of stimulus type, previous congruency (N-1), and previous task repetition. Error bars indicate the standard error of the mean.

† p < . 05 (one-sided), *p < .05, **p < .01, ***p < .001.

Task Performance

Reaction Times. Similar to the task choice analyses, the first trial of each block, error trials and post-error trials were not analyzed. Furthermore, RTs that exceeded more than 3 SDs from the mean were excluded from analyses (0.2%). An ANOVA with *previous congruency* (congruent, incongruent), *current congruency* (congruent, incongruent), *current task* (univalent Simon, bivalent Flanker) as factors revealed a main effect of *current congruency*,

$F(1, 43) = 24.19$, $p < .001$, $\eta_p^2 = .360$, and a main effect of *current task*, $F(1, 43) = 384.75$, $p = .001$, $\eta_p^2 = .899$. Participants responded faster in congruent trials ($M = 533$ ms) than in incongruent trials ($M = 545$ ms) and faster in the bivalent Flanker task ($M = 494$ ms) than in the univalent Simon task ($M = 584$ ms).

A Gratton effect was observed, as indexed by a significant two-way interaction between *current congruency* and *previous congruency*, $F(1, 43) = 14.77$, $p < .001$, $\eta_p^2 = .256$. Furthermore, the two-way interaction between *previous congruency* and *current task* was significant, $F(1, 43) = 4.35$, $p = .043$, $\eta_p^2 = .092$. The three-way interaction between *current congruency, previous congruency*, and *current task* reached also significance, $F(1, 44) = 9.34$, $p = .004$, $\eta_p^2 = .179$.This was due to difference in the strength of the Gratton effect in the two tasks. In the univalent Simon task a robust Gratton effect was found (24 ms), but not in the bivalent Flanker task (1ms).

Error Rates. The first trial of each block and post-error trials were not analyzed. An analogous analysis of the error rates corroborated the results of the reaction time analyses. The main effects of *current congruency*, $F(1, 43) = 14.64$, $p < .001$, $\eta_p^2 = .254$, and *current task*, $F(1, 43) = 26.42$, $p < .001$, $\eta_p^2 = .381$, were significant. There were less errors in congruent trials ($M = 8.7\%$) than in incongruent trials ($M = 10.8\%$), and responses were more accurate in the bivalent Flanker task ($M = 7.7\%$) than in the univalent Simon task ($M = 11.8\%$). A Gratton effect was observed in the error rates as indicated by a significant two-way interaction between the factors *current congruency* and *previous congruency,* $F(1, 43) = 8.31$, $p = .006$, $\eta_p^2 = .162$ (see Table 2 for descriptive statistics).

6.3.3 Discussion

Experiment 5 tested the assumption that tasks with univalent but not bivalent stimuli reveal withdrawal from conflict. Participants switched between a univalent Simon task and a bivalent Flanker task. Conflict in the univalent Simon task was unrelated to the bivalent Flanker task, while a conflict in a bivalent Flanker task resulted from stimuli that were relevant for the Simon task. Switch rates were more frequent after conflict in the univalent Simon task. Again, withdrawal from conflict became only apparent after a previous task alternation, possibly because task-set priming effect masked conflict-withdrawal after previous task repetition trials. However unexpectedly, switch rates were not altered by previous conflict or non-conflict trials in the bivalent Flanker task. In short, the pattern of results confirms that tasks must not involve bivalent stimuli for a sensitive test for the conflict avoidance strategy, while conflict adjustment effects (Gratton effects) are observed in error rates with univalent and bivalent stimulus sets.

6.4 Discussion of Experimental Series B

This series of experiments examined how people adapt their behavior in task performance and task choices to the detection of conflict. As an index for a reactive assimilative strategy, the Gratton effect in task performance (RTs, errors) was measured. In three experiments, an enhanced recruitment of cognitive control following conflict trials was observed: Detection of conflict caused a strengthening of the relevant task dimension and thus facilitated conflict resolution in trials that follow a conflict, as suggested by a reactive assimilative strategy. As an indicator for a reactive accommodative strategy, I measured task choices and observed a bias to switch tasks after conflict, yet only when univalent stimulus sets were used.

It should be noted that the present finding of withdrawal from conflict differ in an important aspect from the demand avoidance effect reported by Botvinick and colleagues (Kool et al., 2010; Botvinick & Rosen, 2009). In their research, demand avoidance is reflected in a bias for the less demanding response option. Crucially, this bias develops gradually over longer series of trials and is a result of a proactive conflict management strategy that is learned over time (cf. Botvinick, 2007). In contrast, the conflict-withdrawal effect observed in the present studies is the outcome of a short lived, reactive escape from aversive situations associated with conflict. Since both tasks involved an equal proportion of conflict trials in Experiments 3 -5, participants could not learn to associate one task with more or less conflict.

In Experiment 3 and in the univalent task in Experiment 5, withdrawal from conflict was restricted to trials that followed a task alternation, presumably because the tendency to withdraw from conflict following a task repetition was overshadowed by task set priming (Monsell, Sumner, & Waters, 2003). Initially, this may seem surprising since research on backward inhibition suggests that switch costs are increased when participants shift to a task they had previously just disengaged from (Mayr & Keele, 2000; Mayr, 2002). It is assumed that the increase in switch costs is due to inhibition of the previously abandoned task (see also Lien & Ruthruff, 2008). Sumner and Ahmed (2006) suggested that the crucial difference between studies that observed task-set priming effects and studies that observed backward inhibition is due to the characteristics of the stimuli employed. Whereas bivalent stimuli call for control to ensure that the correct task is performed and cause backward inhibition, univalent stimuli cause accumulation of task-set priming with increasing repetitions.

The different processing characteristics for uni- and bivalent stimuli can also explain why task difficulty did not influence task choices in this study, although tasks were not matched in their degree of difficulty. Indeed, Yeung (2010) reported an asymmetrical bias in task choice when switching between easy and difficult tasks and explained this result with elevated control of the more demanding task that increases the activation level of this task. As a consequence, disengagement from this task is more difficult. Interestingly, with the bivalent stimulus sets used by Yeung (2010), strong activation of one task goes along with relatively weaker activation of the alternative task. This between-task interference makes it more demanding to disengage from the dominant task. However, with univalent stimuli activation of a task does not necessarily influence the activation level of the alternative task.

To conclude, this series of experiments examined how people manage a conflict situation that allows for two different reactive conflict-management strategies: Recruitment of cognitive control is used to cause performance adjustments to overcome conflict, in line with a reactive assimilative strategy; at the same time, cognitive control is used to withdraw from the source of conflict, in line with a reactive accommodative strategy. Supporting integrative theories of cognitive control (e.g. Botvinick, 2007) results show that people use both conflict-management strategies when confronted with conflict situations.

The following chapter is based on:

Dignath, D., Pfister, R., Eder, A. B., Kiesel, A., & Kunde, W. (2014). Something in the way she moves: Movement trajectories reveal dynamics of self-control. *Psychonomic Bulletin & Review*, *21*(3), 809-816.

Chapter 7

Experimental Series C – Dynamic Withdrawal

After the previous experiments established reactive withdrawal from conflict as robust phenomena when participants are given the choice to avoid the stimulus (Experiment 1 & 2) or to switch to another task (Experiments 3 & 5), the aim of the last series of experiments was to test whether an initial tendency to withdraw from conflict could be observed during movement execution, even when participants are forced to perform a specific action that involves a conflict.

For instance, imagine a child who has a sweet tooth and bellyache from overeating candies. The child knows that consuming more sweets will likely exacerbate the ache whereas consumption of a bitter stomachic medicine provides some relief. To get rid of the bellyache, the child must resist the momentary pleasure of a candy and endure the momentary displeasure of the bitter medicine. Overcoming these impulses is often a very difficult task which possibly involves different conflict management strategies: Even with a very firm determination to swallow the bitter medicine, perhaps the child will grab the medicine bottle very hesitantly at the beginning of the movement and deviate from a direct movement path because of an initial tendency to withdraw from the conflict, before a tendency to resolve conflict takes over. Thus, initially prolonged and circuitous behavior possibly reflects the underlying dynamics of reactive accommodation and proactive assimilation strategies.

The reasoning behind this experimental approach is the assumption that a tug-of-war between antagonistic response options is not ultimately solved before action initiation but leaks into action execution. This is in contrast to most previous research on self-control that examined outcomes of decision processes. Indeed this fits with the assumption of traditional stage models of information processing that a tug-of-war between two competing action plans is resolved prior to action execution (Sternberg, 1969). The execution of the behavior itself is assumed to run more or less encapsulated from the self-control operations, which explains why movement execution was rarely investigated in self-control research.

An alternative approach was advanced by continuous information processing models (Miller, 1988). According to these models, the stream of information from perception to action is continuous and not divided into separate processing stages (Erlhagen & Schöner, 2002). In line with this approach, (Spivey, Grosjean, & Knoblich, 2005) showed that the competition between two choice alternatives is apparent in the trajectory of the movement after a response decision. They asked participants to move a computer mouse to a target picture that either could be phonologically related to the target or not, while a distractor picture was presented on the other side of the screen. Importantly, the trajectories of the computer mouse were recorded, which provided a detailed profile of the movement trajectories during action execution. When the names of the target and the distractor were phonological similar, movement trajectories were attracted towards the distractor (and more so than for phonologically unrelated distractors), revealing dynamic influences of the decision process on action execution (for additional evidence, see Freeman, Ambady, Rule, & Johnson, 2008; Freeman & Ambady, 2011). Thus tracking the trajectories of arm movements during self-control processes might provide a window into the dynamics of conflict management strategies.

7.1 Experiment 6

Experiment 6 measured movement trajectories of the computer mouse quantify a dynamic competition between planned goal-directed actions and temptations. Participants moved a virtual manikin on the computer screen to one of two target areas – a win and a loss target. Approaching the win target was rewarded with 5 points; in contrast, 5 points were subtracted from the total score when the loss target was approached. In each trial, a movement cue indicated whether the manikin should be moved to the win or to the loss target. To ensure a rewarding task structure, the manikin was moved to the win target more frequently than to the loss target. Performing an erroneous response to the loss target in win trials resulted in a subtraction of 5 points, while performing an erroneous response to the win target in loss trials was punished with a subtraction of 10 points. Thus, correctly approaching the loss target in loss trials (i.e., the bitter medicine of the introductory example) subtracted 5 points while approaching the incorrect win target (i.e., sweets) produced an even greater loss (10 points) in these trials.

I reasoned that in *loss trials* movement execution is influenced by behavioral impulses to withdraw from the conflict evoking (correct) loss target. This internal conflict between motivational impulses on the one hand and an intended action on the other hand reflects a self-control dilemma. Thus, although participants agreed to comply with the task instructions, movement execution might reveal the dynamics of withdrawal from conflict and adjustments to overcome conflict. It was expected that movement trajectories in the loss trials deviate from trajectories in the win trials. Specifically, it was hypothesized that trajectories deviate away from the loss target towards the alternative target in the loss trials, even if the manikin finally reached the loss target. This deflection during conflict trials would provide an initial step towards characterizing a behavioral signature of the balance between a reactive accommodative and a proactive assimilative strategy.

As mentioned above, win trials were more frequent than loss trials to maintain a rewarding task structure. Losing too many points likely causes frustration, and participants may not pay attention to the wins and losses if nothing could be gained. From a theoretical point of view, self-control can only be studied if the task requires participants to overcome impulses triggered by temptations. To ensure that a stimulus acts as a temptation, the stimulus either has to already possess an inherent positive valence (e.g., food) or the stimulus has to acquire a positive valence by task procedures. Getting more money than losing money after the execution of a movement arguably endows the corresponding movement target with a positive valence (Schultz, 2006). In addition, more frequent exposure to the win target made it more likely that the win target acquired this positive valence. Consequently, participants are attracted by the win-related target and they have to overcome a spontaneous impulse to move towards the win target (and/or to avoid the loss-related target) when they are instructed to perform a movement towards the loss-related target in loss trials. However, given that the majority of the trials involved a movement to the win target, any differences in the movement trajectories could be due to the unbalanced target frequencies. This obvious confound was addressed with a control condition. The *control condition* was essentially the same as in the *conflict condition* but without involving a motivational conflict. Thus, I expected smaller or no differences between win and loss trials in the movement trajectories for the control condition (without a motivational conflict) relative to the conflict condition (with a motivational conflict). Because win and loss trials only implied wins and losses in the conflict condition, I will refer to the two trial types as high frequent and low frequent trials for the control condition.

7.1.1 Method

Participants

Thirty-three participants (30 women, 3 left handed, 18 -25 years) were recruited and randomly assigned to the *conflict condition* or the *control condition*. One participant in the *conflict condition* had to be excluded due to unusual high error rates (12.6%) in both, *win* and *loss trials* (> 2.5 SDs).

Apparatus and Stimuli

Participants performed their responses with a standard computer mouse ("Fujitsu Notebook Mouse 400NB", Fujitsu Technology Solutions GmbH, Germany) and mouse trajectories were sampled with a frequency of 200 Hz. Stimuli were presented on a 17-inch screen running at a resolution of 1024 x 768 pixels. Three empty boxes (50 pixels x 50 pixels) were displayed on a black background. Two target boxes designating target areas were presented in the upper third of the screen, one to the left (midpoint in pixels: x = 281, y = 217) and one to right (x = 793, y = 217; co-ordinates are given relative to the upper left corner of the screen). Each target box contained a picture of either a smiley or a frowny (see Fig. 12). Location of smiley and frowny pictures changed randomly from trial to trial. An empty start box was displayed in the lower center of the screen (x = 512, y = 709). The mouse cursor displayed a small manikin (28 pixels x 50 pixels). In the *conflict condition*, an ascending tone (win trials) and a descending tone (loss trials) with a duration of 400 ms was used to indicate that participants reached the target area. Ascending and descending tones were chosen to make the mapping of wins and losses to the target location more obvious for the participants. In the *control condition,* a neutral 400 Hz or 600 Hz tone was presented for 400 ms.

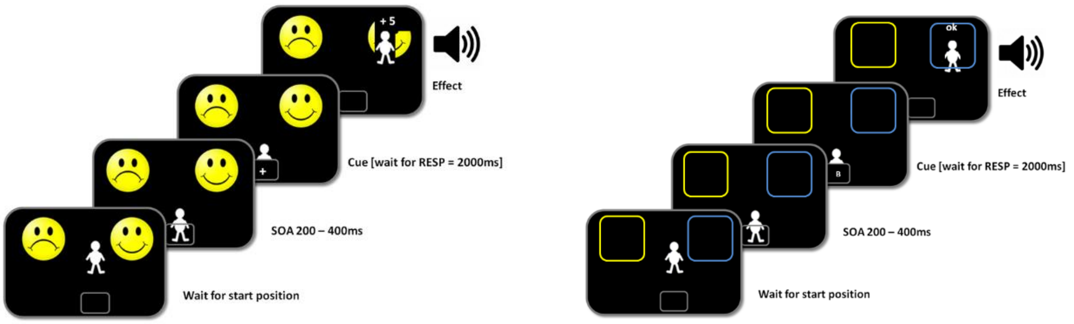

Figure 12. Trial sequence for Experiment 6. The *left panel* shows the conflict condition, the *right panel* shows the control condition. Participants moved the manikin with the computer mouse into the start area at the bottom of the screen. Subsequently, a cue specified the correct response and auditory and visual feedback was provided when participants arrived at one of the target boxes.

Procedure and Design

At the start of a trial, a movement cue (+ or -) appeared in the start-box (see Freeman & Ambady, 2009 for a similar procedure). If a "+" appeared in the box, participants were to move the manikin as quickly as possible to the smiley-box, resulting in a win of 5 points. If the cue was a "-", participants were to move the manikin to the frowny-box, resulting in a loss of five points. Ten points were subtracted when the manikin did not reach the designated target within 2 seconds. A counter in the upper left corner of the screen displayed the total point score throughout the experiment. Participants were informed that they would get a chocolate bar as a bonus reward when their score exceeded a certain (but not further defined) threshold at the end of the session.

After 10 training trials in which no points were earned or lost, participants worked through 200 experimental trials. In the *conflict condition*, these trials consisted of 170 win trials and 30 loss trials. At the start of each trial, the empty start-box and the target-boxes with a smiley or frowny appeared on the screen. Participants initiated a trial by moving the manikin from the middle of the screen to the start-box. Then, the movement cue appeared in the start box after a random interval (200-400 ms). Upon arrival in one of the target areas, a tone was played and the amount of points that were earned or lost in this trial popped up above the box (e.g., +5). If participants selected the incorrect target area or did not reach the target area within 2 seconds, an error message appeared on the screen for 2 s, indicating the loss of 10 points.

In the *control condition*, the target-boxes were shown with a blue or yellow frame. One color (counterbalanced across participants) was cued in 170 of the trials (*high frequent trials)* whereas the other color was cued only in 30 trials (*low frequent trials)*. Movement cues were the letters "b" (blue) and "g" (yellow) that appeared in the start-box. Tones were a 400 Hz or

600 Hz tone without affective connotation. Importantly, participants could not earn or loose points in this condition. In case of a correct response, “ok” popped up above the box. In case of a time-out or a wrong response, an error message was displayed on the screen for 2 s.

Data processing

RT was measured from onset of the cue until the manikin left the start-box and movement time (MT) was measured as the time between leaving the start-box and arriving at the target-box. Trials with RTs or MTs deviating more than 2.5 standard deviations from the participant´s mean RT or MT were discarded, calculated separately for win/high frequency trials and loss/low frequency trials (*conflict condition*: 4.6%; *control condition* 4.8%). Trials with time-outs (*conflict condition*: < .01%; *control condition*: no omissions), response anticipations (i.e., when the manikin left the start-box before cue onset; *conflict condition:* 7.3%; *control condition*: 7.5%) and incorrect responses (*conflict condition*: 2.1%; *control condition*: 0.7%) were excluded from the analyses. Each trajectory was aligned to a common starting position (horizontal middle position) and time-normalized to 101 equidistant time slices, excluding the data of the RT interval. Trajectories to the left side were mirrored for analysis. Then two additional dependent variables were calculated for each trial: Maximum absolute distance (MAD) and area under the curve (AUC). MAD is defined as the maximum distance between a trajectory and a straight line from the start point to the end point of this trajectory. MAD is coded positive for curves towards the alternative target and negative for curves away from it. AUC is defined as the area between the trajectory and the straight line. Trials with MADs or AUCs deviating more than 2.5 standard deviations from the participant´s mean MAD or AUC were discarded, calculated separately for win/high frequency trials and loss/low frequency trials (*conflict condition*: 3.9%; *control condition* 3.9%).

7.1.2 Results

For a direct comparison of the conflict and the control condition, the data was first submitted to mixed ANOVAs with condition (*conflict* vs. *control*) as a between-subjects factor and trial type (conflict condition: *win trials* vs. *loss trials*; control condition: *high-frequent vs. low-frequent*) as a within-subject factor. For all dependent variables, the interaction of condition and trial type were significant or approached significance, indicating that the impact of trial type differed between conditions; RT: $F(1, 32) = 16.01$, $p < .001$, $\eta_p^2 = .33$; MT: $F(1, 32) = 4.49$, $p < .05$, $\eta_p^2 = .12$; error rates: $F(1, 32) = 6.91$, $p < .05$, $\eta_p^2 = .17$; MAD: $F(1, 32) = 6.11$, $p < .05$, $\eta_p^2 = .16$; AUC: $F(1, 32) = 3.35$, $p = .078$, $\eta_p^2 = .09$). Consequently the influence of trial type was analyzed separately for each condition.

Conflict condition

As can be seen in Figure 13, reaction times were longer in *loss trials* (643 ms) than in *win trials* (559 ms), $t(15) = 6.18$, $p < .001$, d = 1.54, and an analogous effect was observed for MT: Participants needed more time to reach the target-area in *loss trials* (307 ms) than in *win trials* (270 ms), $t(15) = 2.76$, $p < .05$, $d = 0.69$. A comparison of the trajectory data between the two trial types revealed that movements in *loss trials* deviated away from the loss target towards the win target, whereas no such bias was evident in win trials (Fig. 14). Accordingly, there was a significant difference between trial types for both MAD, $t(15) = 3.63$, $p < .005$, d = 0.91, and AUC, $t(15) = 3.26$, $p < .01$, d = 0.81.

The pattern of reaction times and mouse trajectories is mirrored by the error data. Errors were more frequent in *loss trials* (M = 5.3%) than in *win trials* (M = 1.8%), $t(15) = 2.48$, $p < .05$, d = 0.62, despite the higher penalty that incurred for *loss trials*.

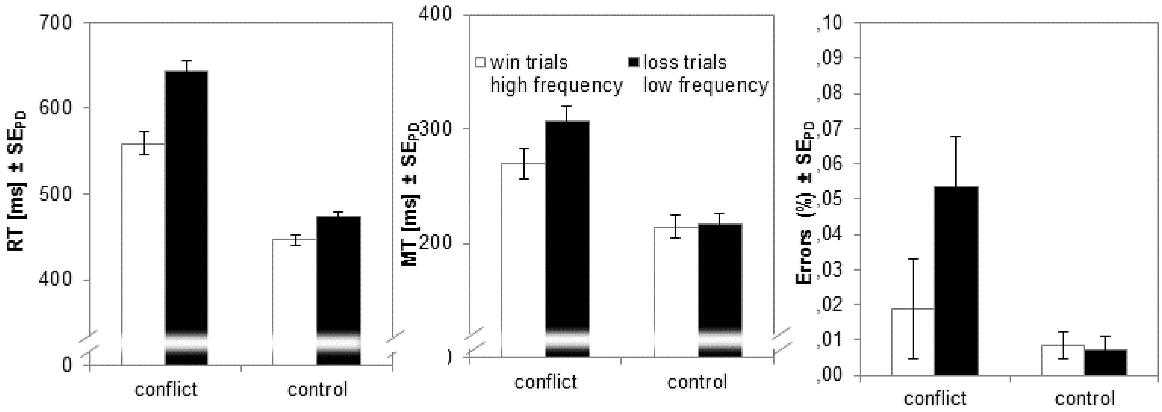

Figure 13 Mean reaction time (RT), movement time (MT) and error rates for the two conditions (*win trials/high-frequent trials vs. loss trials/low-frequent trials)* for the conflict and the control condition in Experiment 6. Error bars show standard errors of paired differences, computed separately for each condition (Pfister & Janczyk, 2013).

Control condition

Reaction times were longer for *low frequent trials* (473 ms) than for *high frequent trials* (446 ms), $t(17) = 4.69$, $p < .001$, d = 1.11. However, *t*-tests for MT, MAD, AUC and error-rate showed no differences, all *ps* > .250.

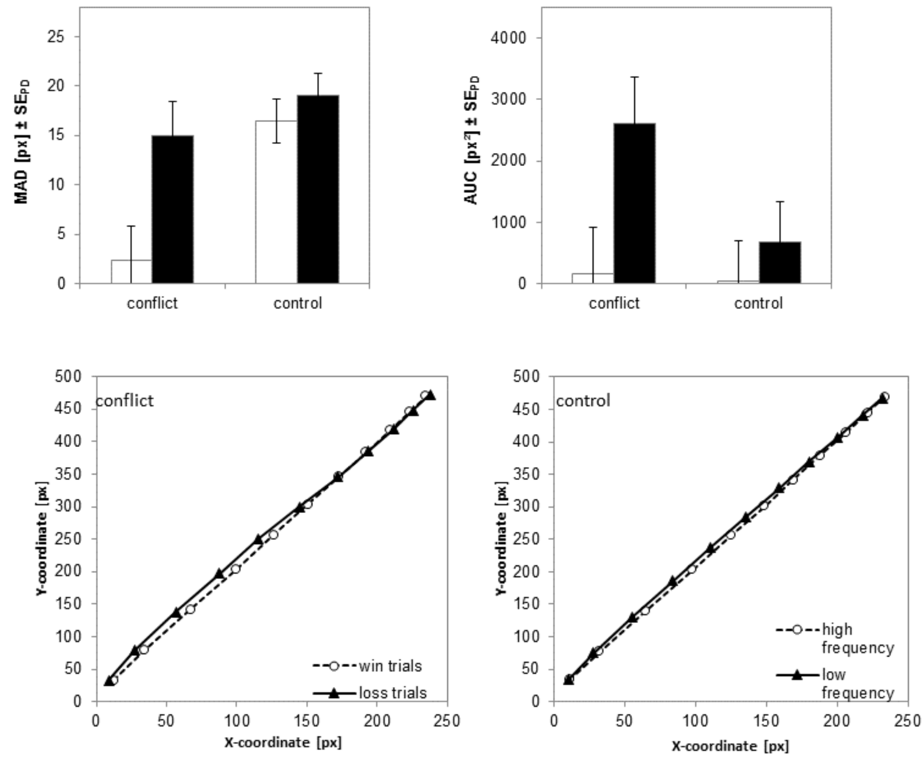

Figure 14 *Upper panel*: Mean maximum absolute distance (MAD) and area under the curve (AUC) for the two conditions (*win trials/high-frequent trials vs. loss trials/low-frequent trials)* for the conflict and the control condition in Experiment 6. Error bars show standard errors of paired differences, computed separately for each condition (Pfister & Janczyk, 2013). *Lower panel*: Mean movement trajectory for the two conditions (*loss trials/low-frequent trials vs. win trials/high-frequent trials)* for the conflict condition (left side) and the control condition (right side) in Experiment 6.

7.1.3 Discussion

Consistent with the predictions, movement trajectories differed markedly between *loss* and *win trials* in the *conflict condition*. When participants moved the manikin towards the loss target, movement trajectories were deflected more than when they moved the manikin to the win target. Conceivably this effect in the movement trajectories is in line with the idea of an ongoing conflict between motivational impulses and instructed action intentions and possibly reflects an initial tendency to withdraw from conflict. A self-control conflict is also supported by increased reaction times, movement times and error rates in the *loss trials*. Importantly, in the *control condition* with the same movement frequencies but without affective-motivational consequences only the reaction times differed between *high frequent trials* and *low frequent trials*. Movement trajectories, however, were not different in this condition. The absence of a comparable effect in the control condition strongly argues against the possibility that the deviation of the trajectory in the *conflict condition* was merely driven by the infrequency of the response.

For Experiment 6 it is unclear, however, whether the effect in the movement trajectories occurred because of a biased processing of the emotional stimuli that were presented in the target area (i.e., a smiley and grumpy) or because of the associations with wins and losses. Thus, it is possible that the effect in the movement trajectories was induced by the emotional faces and not by a motivational conflict. This question is examined further in Experiment 7.

7.2 Experiment 7

To provide a more conclusive test of a self-control conflict during movement execution and an initial conflict withdrawal tendency, an additional experiment was conducted that did not present emotional stimuli. The experimental design was identical with the conflict condition of Experiment 6 with the major change that neutral colors were used to signal the target areas producing wins and losses. Thus, no emotional faces were presented in this experiment, ruling out an explanation with biased-processing of emotional faces.

7.2 Method

Participants and Procedure

Eighteen participants (14 women, 1 left handed; 19–30 years) were paid for their participation.

Experiment 7 involved three major changes in comparison to the conflict condition of Experiment 6. First, win and loss targets were represented by blue or yellow target boxes (counterbalanced across participants) that replaced the emotional faces. Second, movement cues were the letters “b” and “g”. Participants were to move the manikin to the blue box when the letter “b” (German “blau”, blue) appeared in the start-box and to the yellow-box when the letter “g” appeared in the start-box (German “gelb”, yellow). Thirdly, no tones were presented after reaching the target-box.

Participants worked through 200 experimental trials that consisted of 170 win trials and 30 loss trials. Participants were informed about the color association with wins and losses. Instructions emphasized that five points are added to the point score when the manikin reaches the colored box associated with a win; in contrast, five points are subtracted from the total score when the manikin reaches the colored box associated with a loss. Erroneous and omitted responses were penalized with a subtraction of 10 points. All other procedural details were identical with those of the conflict condition in Experiment 6.

Data processing

Trials with RTs/ MTs/ MADs/ AUCs deviating more than 2.5 standard deviations from the participant´s mean RT/ MT/ MAD/ AUC were discarded, calculated separately for win and loss trials (RT/ MT: 4.7 %; MAD/ AUC: 3.3%). Trials with time-outs (0.03%), response anticipations (7.7%) and incorrect responses (0.05%) were excluded from the analyses. Informal visual inspection of the movement data indicated that one participant showed a particularly pronounced curved trajectory. Z-transformation of the means of the trajectory data revealed that MAD and AUC of this participant exceeded 3 standard deviations from the samples mean MAD or AUC. Therefore, this data set was removed from the analyses. Including the participant in the analyses did not change the pattern of results.

7.2.2 Results

Reaction times in *loss trials* (484 ms) were longer than in *win trials* (430 ms), $t(16) = 6.23$, $p < .001$, d = 1.55. An analogous effect was observed for MT: Participants needed more time to reach the target area in *loss trials* (336 ms) than in *win trials* (317 ms), $t(16) = 2.35$, $p < .01$, d = 0.74. A comparison of the trajectory data between the two trial types showed that movements in the *loss trials* deviated away from the loss target towards the win target and that this effect was more pronounced than the reverse deviation in *win trials*. This difference was significant for both, MAD, $t(16) = 3.77$, $p < .001$, d = 0.88, and for AUC, $t(16) = 3.43$, $p < .001$, d = 0.78 (see Fig. 15)

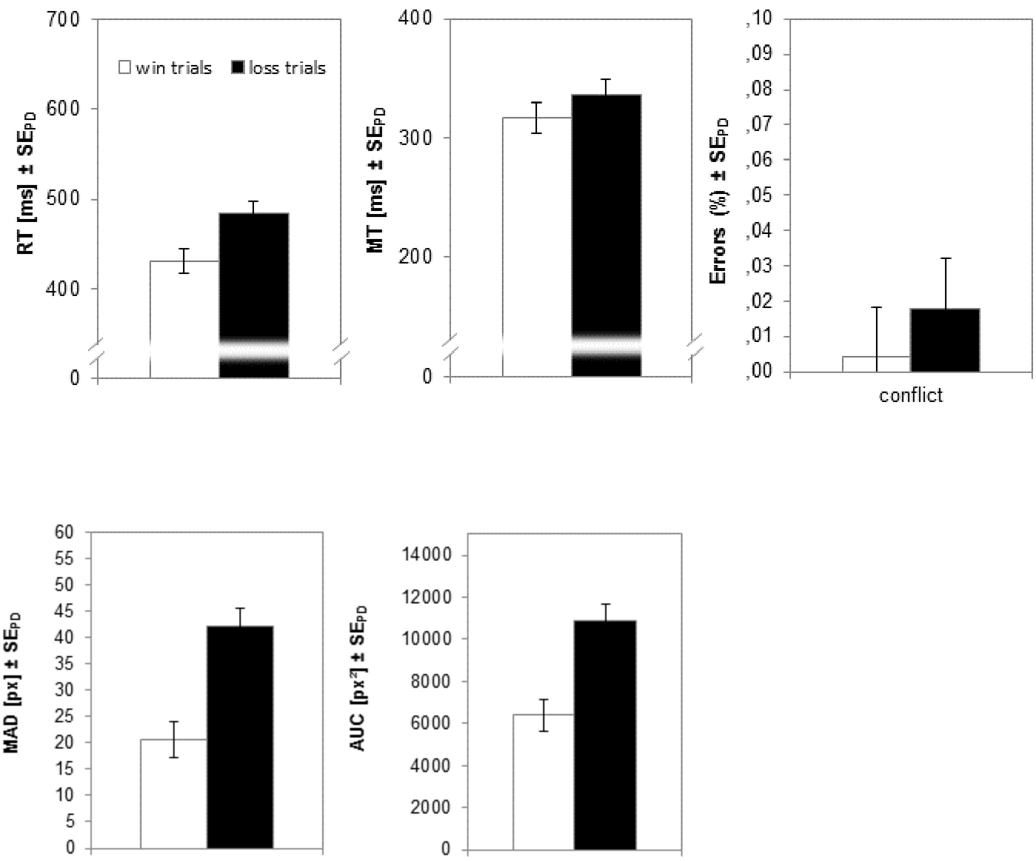

Figure 15 Mean reaction time (RT), movement time (MT) and error rates (*upper panel*) and mean maximal absolute distance (MAD) and area under the curve (AUC) (*lower panel*) in win trials and loss trials of Experiment 2. Error bars show standard errors of paired differences (Pfister & Janczyk, 2013).

The pattern of movement errors was in line with the reaction times and mouse trajectories analyses, with more errors in *loss trials* (M = 1.7%) than in *win trials* (M = 0.3 %); this difference reached significance in a one-tailed test, $t(16) = 1.78$, $p < .05$, d = 0.43. However, this analysis has to be treated with caution, since errors were in general quite rare.

Comparison of Experiment 6 and 7

To compare the results of Experiment 6 and Experiment 7, I submitted the data to a 3 (Experiment 6, *conflict condition*; Experiment 6, *control condition*; Experiment 7, *conflict condition*) x 2 (*win/high-frequent* vs. *loss/low-frequent trials*) ANOVA. Only results for main variables of interest, MAD and AUC, are reported here. The main effect of *Experiment* was significant for MAD, $F(2, 48) = 8.31$, $p < .01$, $\eta_p^2 = .257$, and AUC, $F(2, 48) = 15.13$, $p < .001$, $\eta_p^2 = .387$. The main effect of *trial type* was significant for MAD, $F(1, 48) = 26.29$, $p < .001$, $\eta_p^2 = .354$, and for AUC, $F(1, 48) = 19.51$, $p < .001$, $\eta_p^2 = .289$. Furthermore, the interaction between *Experiment* and *trial type* was significant for MAD, $F(2, 48) = 5.37$, $p < .01$, $\eta_p^2 = .183$ and AUC, $F(2, 48) = 3.88$, $p < .05$, $\eta_p^2 = .139$.

Planned comparisons revealed that the effect of trial type on the movement trajectories in the *conflict condition* of Experiment 6 and Experiment 7 was not different for MAD (T (48) = 1.49, $p > .05$) nor for AUC (T (48) = 1.42, $p > .05$). However, both effects differed significantly from the *control condition* of Experiment 1 in MAD, $F(1, 48) = 2.89$, $p < .01$, and in AUC, $F(1, 48) = 2.36$, $p < .05$.

7.2.3 Discussion

Experiment 7 replicated the effect of self-control conflict in movement execution without presentation of emotional faces in the target areas and without feedback of ascending/descending tones. This finding rules out an alternative explanation in terms of a bias processing of emotional stimuli. In addition it eliminates a potential confound with the affective quality of the sounds (see Horstmann, 2010). Instead, the results support the idea that the movement trajectories were influenced by motivational impulses to approach rewards (win) and/or avoid punishments (loss).

7.3 Discussion of Experimental Series C

This series of experiments examined the influence of an initial tendency to withdraw from conflict on action execution. Importantly, participants in Experiments 6 and 7 were forced to perform a specific action that resembled a conflict situation. To reveal the dynamics of conflict management strategies, continuous mouse trajectories towards small rewards (winning points) and punishments (loss of points) were recorded. Two experiments provided clear evidence that accepting a short-term punishment to prevent an even greater long-term punishment causes a self-control conflict, as indicated by increased RTs and errors rates in these trials compared to reward trials. More interestingly, movement trajectories were deflected more when participants moved towards punishments than when they moved towards rewards. A possible interpretation of this finding would assume that this deflection indicated a tendency to withdraw from the conflict situation. After the initial implementation of a reactive accommodation strategy, a subsequent proactive assimilative strategy caused participants to accept the short-term punishment and to overcome the conflict.

However, in the present research both the tendency to withdraw but also a motivational tendency to approach the rewarding non-target (the ´tempting´ stimulus), may have contributed to the observed effects, inducing different types of self-regulatory conflict in the loss trials: (1) A conflict between an automatic impulse to avoid the loss target (e.g. a reactive accommodation strategy) and the intention to avoid an even greater loss by moving the manikin to this target. (2) A conflict between an automatic impulse to approach the win target and the intention to move the manikin to the loss target in line with the task instructions. Furthermore, it is possible that approach and avoidance tendencies affected the movement trajectory simultaneously. Further research is necessary to clarify whether the deflection in the movement trajectories during loss trials was caused by a reactive accommodation strategy or by a motivational tendency to approach the (tempting) reward targets or by a synergy of both.

However, approach tendencies towards the non-conflicting option not necessarily contradict a reactive accommodation strategy. Evaluations or feeling states are inherently contrastive (e.g. Eder & Dignath, 2013; Parducci, 1984). For instance, neutral events are judged to be more pleasant when compared with unpleasant alternatives. Conversely, the same neutral events are judged to be more unpleasant when compared with pleasant alternatives. Thus the ´tempting´ alternative option could have acquired a more positive valence compared to the negative valence elicited by the conflict. A more speculative interpretation of this finding would assume that a reactive accommodation strategy not only comprises a tendency to withdraw from conflict and to disengage from the conflict task, but simultaneously comprises a tendency to approach alternative options and engage in alternative tasks.

On a more general note, the results of experiment 6 and 7 challenge theories of self-control that are mostly concerned with decision making processes and analyze behavior typically in terms of the achieved results (e.g. Friese & Hofmann, 2009). The means by which these goals are achieved (i.e., action execution), however, are often overlooked. By quantifying action dynamics, the present experiments demonstrated a self-control conflict not only in reaction times and error rates but also in the execution of a movement. Thus, a tug-of-war between antagonistic action tendencies appears to leak into action execution – a finding that is in line with dynamical action models that assume a constant accumulation of information and ongoing decision processes until the behavior is terminated (Spivey, 2007).

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Chapter 8

Summary of the Empirical Part

Three series of experiments tested whether participants withdraw from a conflict situation. This was motivated by a novel control taxonomy, the conflict management framework. A central conjecture which derived from this classification was that different control strategies are recruited to counteract conflict: (i) a reactive assimilation strategy, causing adjustments of control to overcome conflict, (ii) a proactive assimilation strategy that allows an anticipatory shielding of goals to overcome conflict, (iii) a proactive accommodation strategy, driving the preventive avoidance of conflict situations and (iv) a reactive accommodation strategy, facilitating a tendency to withdraw from conflict situations. Since empirical evidence for the latter of the four strategies was scarce until now, the present thesis aimed to support the conflict management framework by providing evidence for this strategy.

Experiments 1 and 2 tested whether basic motivational action tendencies like approach and avoidance would provide means to withdraw from conflict situations. Therefore, participants performed an induction phase in which stimuli became associated with different levels of conflict. In a subsequent test phase, these conflict-associated stimuli were presented and participants responded with either an approach or an avoidance response. Results showed that conflict stimuli associated with increased levels of conflict facilitated the initiation of avoidance responses in a forced choice test (Experiment 1) and elicited more avoidance responses in a free choice test (Experiment 2) in comparison to approach responses. These findings point to avoidance motivation as a means to withdraw from conflict and are well in line with a reactive accommodation strategy.

Experiments 3-5 focused on decision-making as a means to withdraw from conflict. A free choice test situation was used in combination with two response interference tasks. In Experiment 3, participants chose on each trial between two tasks with univalent stimuli. Switch rates increased following conflict trials, indicating withdrawal from the source of conflict. Performance measures were analyzed in addition to task choices. Sequential trial-to-trial variation in control (Gratton effect) indicated an adjustment of control to overcome conflict. Thus, Experiment 3 provided evidence for a jointly implementation of a reactive accommodation and a reactive assimilation strategy in one paradigm.

Experiment 4 specified necessary conditions for a reactive accommodation strategy more precisely by employing bivalent stimuli. With bivalent stimuli, switch rates were not increased following conflict trials, but switches occurred less often after conflict. Arguably, bivalent stimuli make withdrawal from conflict less likely because they entail relevant attributes for both tasks. Thus, with bivalent stimuli participants could not avoid the source of conflict. In Experiment 5 tasks were used that comprised of univalent or bivalent stimuli. Here, only tasks with univalent stimuli revealed conflict withdrawal, whereas conflict adjustment was found for all tasks. To summarize, Experimental series B provided evidence for a reactive accommodation strategy when withdrawal to another task allowed avoidance of the current conflict situation. Regardless whether a reactive accommodation strategy could be implemented, all experiments provided evidence for a reactive assimilation strategy.

Importantly, this is first evidence that both reactive strategies can be recruited simultaneously in one paradigm.

Whereas previous experiments focused on withdrawal from conflict in action selection, Experiments 6-7 revealed a tendency to withdraw from conflict during action execution. This series of experiments showed that an initial tendency to withdraw from conflict was expressed during the execution of a movement. More precisely, two experiments found that movement trajectories deviated away from the conflicting goal location. Importantly, this initial deflection of movement trajectories was observed even though participants successfully solved the self-control conflict in the end. Arguably, the results point to a sequential implementation of different conflict strategies. Whereas initial deviations away from conflicting stimuli indicate a reactive accommodation strategy, the final movement towards the conflict stimuli overcomes conflict, indicating a proactive assimilation strategy. Careful analysis of continuous movement trajectories unfolding over time might provide a window into the dynamics of multiple conflict management strategies. It should be noted that Experiments 6 and 7 were not designed to tear apart the influence of the conflicting stimulus and the ´tempting´ alternative stimulus on movement trajectories. However, it is quite plausible that a reactive accommodation strategy entails not only mechanisms to disengage from a task (withdrawal from conflict), but also mechanisms to re-engage in an alternative task (approach of the alternative stimulus). One way to facilitate the re-engagement in an alternative task would be to revalue the alternative task in contrast to the conflict associated task.

To conclude, the empirical part of this thesis aimed to support the conflict management framework by providing evidence for a reactive accommodation strategy. Seven experiments with three different paradigms tested whether conflict causes a tendency to withdraw from conflict provoking situations. Results provided strong evidence for reactive withdrawal as an adaptive response to conflict in reaction times (Experiments 1, 6 & 7), choice rates (Experiments 2, 3 & 5) and movement trajectories (Experiments 6 & 7). In the remainder of the discussion, I will outline how conflict management can provide a useful framework to generate new hypothesis and stimulate further research. In the course of this analysis, I will spell out a process model of flexible conflict management as an account for the some of the data.

Then I will address in more detail why the reactive accommodative strategy is adaptive and how this strategy relates to previous findings in the literature. Finally, I will discuss cases where the balance between the different conflict management strategies was lost and I will submit a new look on self-control failures.

Chapter 9

Flexible Conflict Management

Theoretically, the goal of this dissertation was to account for the variability of how conflict situations are mastered. The proposed conflict management framework acknowledges this variability by systematically identifying four different behavioral strategies how people deal with conflicts: (i) In anticipation of a conflict, people can prepare for high control demands to overcome the conflict and implement a proactive assimilative control strategy. (ii) Alternatively, the anticipation of conflict can lead to the avoidance of the conflict situation, achieved by a proactive accommodation control strategy. (iii) Furthermore, when conflict already has occurred, a reactive assimilation control strategy allows for adjustments of control to overcome a conflict. (iv) Finally, a reactive accommodative control strategy allows for spontaneous withdrawal from the conflict situation.

However, decomposing control into different conflict strategies is only half of the story. In reverse, future research will have to show how these strategies relate to each other and they are orchestrated to give rise to the enormous flexibility of human behavior on the one hand and to allow a remarkable persistence on the other hand.

Paradoxically, balancing opposing conflict strategies according to different adaptive challenges might create the potential for new conflict. Goschke (2003; 2013) used the term “meta-control dilemma” to refer to this multi constraint-satisfaction problem that results from antagonistic conflict-management strategies. Exemplarily, the following section will spell out such a meta-control dilemma in more detail for the stability-flexibility dimension. The importance to maintain an adequate balance of stability and flexibility becomes obvious when the conflict-management strategies are out of balance (Allport, 1989; Goschke, 2000). For example, some patients with frontal lobe damage show so-called “preservation errors” in tasks that require an updating and maintenance of varying task rules (e.g., the Wisconsin card sorting task). These patients suffer from a deficit in flexibility (Milner, 1963). In contrast, other patients with frontal lobe damage suffer from a deficit in stability and show shortcomings to resist goal incompatible action tendencies triggered by some object irrespective of the current goal (Duncan, 1986; Lhermitte, 1983).

9.1 How to Control the Control Strategies

Thus, a meta-control dilemma perspective poses several interesting questions for future research on the conflict management account. In the following, I will discuss the most pressing ones in more detail. First, an essential assumption of the conflict management framework is that different conflict-management strategies operate on different time scales (cf. Braver, 2012). It is unclear how proactive and reactive conflict-management strategies on are geared to each other. In particular, since proactive and reactive control of the same conflict management strategy (e.g. assimilation) are dissociable (Funes, et al., 2010; Braver et al., 2009) this interaction might be non-trivial and involve several intervening processes.

Second, under what conditions recruit individuals assimilative strategies, under what conditions do they recruit an accommodative strategy? This problem arises by the critical assumption that all conflict management strategies rely on the same conflict signal. One possibility is that assimilation and accommodation strategies are operating mostly on different stages or levels of action control. For instance, in order to withdraw from a conflict situation, one needs to change the *selection* an alternative task. In order to overcome a conflict one needs to adjust *performance* within the current task.

Finally, even if one confines analysis to one particular time scale of control (e.g. reactive) it is unclear how antagonistic demands on control are regulated. Theoretically, there are three possibilities how both flexible and stable strategies may relate to each other. First, it is possible that both strategies are mutually exclusive: Participants respond either with assimilation or with accommodation to conflict, but they cannot do both at the same time. Alternatively, it is possible that both strategies are used at the same time but independent of each other. For instance participants use one strategy to control performance and the other to control choice behavior. A third possibility is that both strategies rely on a common cognitive mechanism so that participants who are efficient in one strategy are also efficient in the use of the other one.

To illustrate how the question 2 and 3 could be addressed, I will spell out a process model how an aversive conflict signal could possibly guide assimilation and accommodation in parallel. Although rather simple, these models have been proven very useful to make theoretical predictions explicit and consequently allow testable prediction for future research (cf. Botvinick, 2007). The present model addresses the voluntary task-switching paradigm used in experiments 3, 4 and 5 and aims to account for this data. Therefore, I will confine the analyses to a reactive control mode. At the end of the section it will be briefly discussed how this model could be extended to account for proactive control, too.

9.2 Flexible Conflict Management: A Process Model

According to several theories of task switching, situations like the experimental paradigm employed in experiment 3-5 can be distinguished between processes of task selection and task performance (e.g. Logan & Gordon, 2001; Mayr & Kliegl, 2003; Rubinstein, Meyer, & Evans, 2001). For instance, the executive control theory of visual attention (Logan & Gordan, 2001) assumes that task sets are represented on two different levels, the task level and the parameter level. The task level representation consists of the instructions and rules that guide a specific task. In the present paradigm, this would be equivalent to task choices. The parameter level representation specifies the S-R association that leads to task completion, which would be equivalent to task performance in the present paradigm. Such a hierarchical view of task representations is well in line with recent empirical work on task switching (Lien & Ruthruff, 2008; Schneider & Logan, 2006; Weaver & Arrington, 2013). For instance, Arrington and co-workers (Arrington & Yates, 2009; Butler, Arrington, & Weywadt, 2011) used a correlation approach to dissociate task choice and task performance. The authors combined the VTS paradigm with an assessment of executive functions and found a correlation between executive function and task performance, not between executive function and task choice though.

At the core of the proposed process model of reactive conflict management is the distinction between levels of representation - on the one hand representations at a *task choice* level and on the other hand representations at a *task performance* level (Figure 16, left panel shows a graphical sketch of the model). The model extends and integrates the conflict-monitoring model that can account for conflict adjustment (Botvinick et al., 2001; see Box 1) with Botvinick's (2007; see Box 2) model that can account for conflict avoidance. Although some models have already addressed conflict adjustment in a task switching context (Brown, Reynolds, & Braver, 2007; Verguts & Notebaert, 2008), these models are not appropriate for the present analysis because they focused on cued task switching and not on voluntary task switching.

Following Logan and Gordon (2001), I assume a separation of task choice and task performance processes. More precisely, it is conjectured that conflict monitoring can account well for the task performance level, whereas the Botvinick (2007) model can account well for the task choice level. Due to the task-switching situation in the present paradigm, there are four task demand units. Each unit represents a relevant and an irrelevant feature of the respective task. For instance, task demand units for the Flanker task include the identity of the central letter as the relevant task feature and the peripheral letter as the irrelevant task feature. Task demand units for the Simon task include the identity of the digit as the relevant task feature and the location of the digit as the irrelevant task feature. Task demand units have connections to two different levels of representation: On the one hand, task demand units propagate to the input layer at the task performance level and bias information processing according to the currently relevant task set. The model includes input units that code for the identity of the central letter and the identity of the digit. Furthermore, input units also code for the distractor letters and the location of the digit. On the other hand, task demand units propagate to task choice units at the task choice level. The model includes a task choice unit for the Flanker task and a task choice unit for the Simon task.

In line with the conflict monitoring model, it is assumed that conflict is the result of a parallel activation at the response unit and is defined as the simultaneous activation of mutually inhibitory units (Botvinick et al., 2001). For instance, in incongruent Simon trials the activation due to the identity of a digit and activation due to the location of the digit causes strong activation of mutually exclusive responses. This conflict signal or ´energy´ is quantified by the product of the activation level of all input units connected to the response unit (Hopfield, 1982; cf. Botvinick et al., 2001). Conflict is detected by a conflict monitor that passes this information to the task demands units (cf. Botvinick et al., 2001) and in addition also to the task choice units (cf. Botvinick, 2007). With this architecture in mind, I will address several points concerning the models´ operating characteristics in the following.

How can the model explain the simultaneous implementation of conflict adjustment and conflict withdrawal? According to the model, the conflict signal has distinct effects on the different hierarchies of task representations. Now, at the task choice level, the weights of each task are altered by the conflict signal (cf. Botvinick, 2007) and the last active task choice unit is *weakened*. Consequently, the selection of tasks is biased away from the previously active task representation, explaining conflict avoidance. At the task performance level, conflict causes a strengthening of the relevant dimension and a weakening of the irrelevant dimension, giving rise to conflict adjustment (cf. Botvinick et al., 2001). Thus, conflict has *opposing effects* on the task choice and the task performance level, respectively, allowing for a simultaneous implementation of a reactive accommodation and a reactive assimilation strategy at different levels of representation.

How can the model explain the diverging results for univalent and bivalent stimuli?

The model above was described for a situation with two univalent tasks (Experiment 3; Experiment 5: Simon task). Here, weakening of the irrelevant dimension of a task 1 does not affect an alternative task 2. If conflict at the task level reduces the strength of task 1, task 2 will be favored over A. Now consider a situation with two bivalent tasks (e.g. Experiment 4; for a graphical sketch, see figure 16, right panel). Here, weakening of the irrelevant dimension of task 1 affects the alternative task 2, because the irrelevant dimension of one task is also the relevant dimension of the other task. To illustrate this, consider the bivalent stimuli in Experiment 4 (e.g. "3B"). To resolve conflict in the digit task, the irrelevant dimension (the number task) is weakened. Critically, with bivalent stimuli this ´down-regulation´ of irrelevant task features on the performance level influences decision-making at the task choice level. In contrast, this is not the case with univalent stimuli (see above for a more detailed description for univalent stimuli).

It is assumed that the propagation from the task demand units is more persistent than the signal that arrives from the conflict monitor unit (probably due to different degrees of noise). Thus, even if conflict at the task choice level reduces the strength of task 1, task 2 is still not favored over task 1. This is because weakening of the irrelevant dimension of task 1 also reduces activation of the relevant dimension of task 2, resulting in a stronger activation of task 1 over task 2. Thus, conflict avoidance is not observed with bivalent stimuli, and task switching is observed only following non-conflict trials.

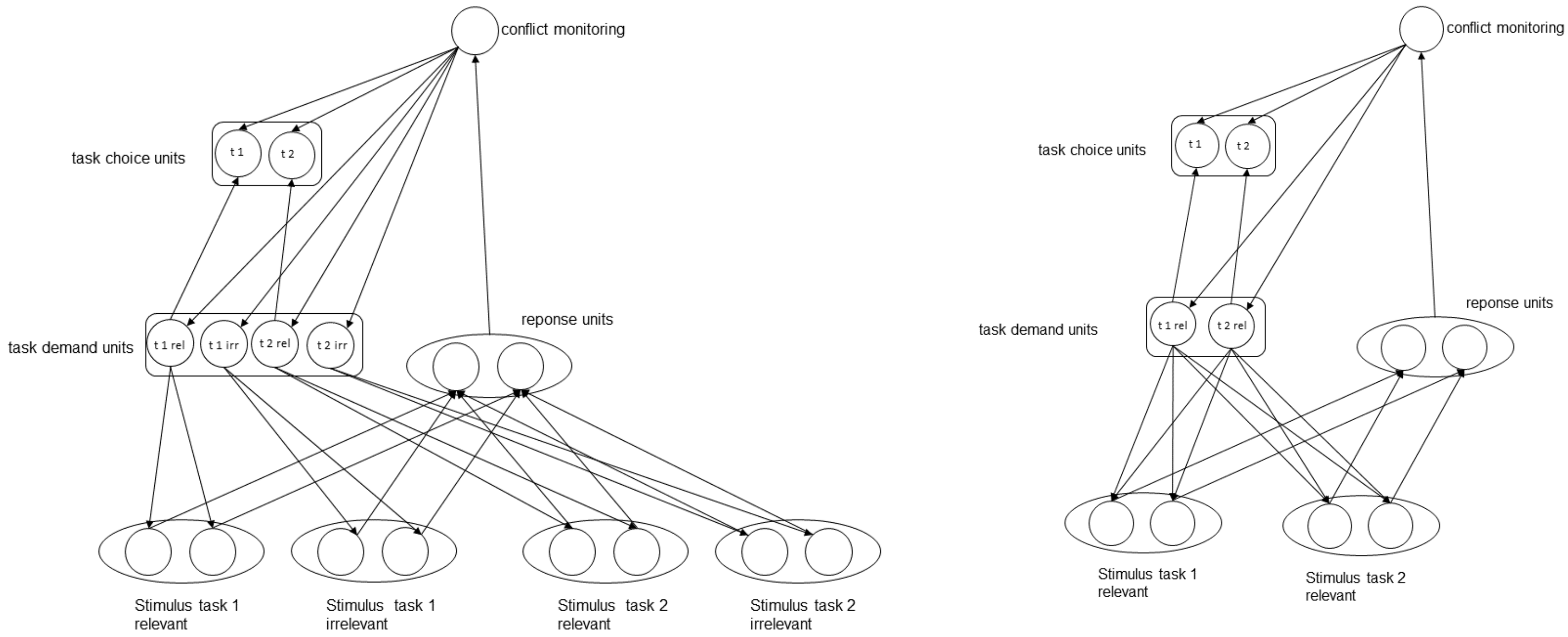

Figure 16. A graphical sketch of the model for univalent stimuli (*left panel*) and for bivalent stimuli (*right panel*).

How can the model explain the reactive conflict withdrawal effect?

A core assumption of an integrated account of conflict withdrawal and conflict adjustment is that conflict is registered as an aversive signal. In line with Botvinick (2007), it is assumed that conflict biases task choice away from the task associated with conflict. In the Botvinick model, an association between conflict and a task accumulates gradually over time. However, Botvinick also assumed that conflict that is more recent has a stronger impact on learning than conflict several trials back. Thus, I conjecture that by adjusting the learning parameter, the model can not only account for sustained control like a proactive accommodation strategy (e.g. the demand avoidance effect) but also for more transient control like a reactive accommodation strategy (e.g. conflict-withdrawal effect, Experiment 3 & 5). Another, not mutually exclusive explanation for a reactive avoidance of conflict is that the aversive quality of conflict triggers an automatic motivational tendency to avoid the source of the conflict (see Experiments 1 & 2). For example, research on motivational avoidance-avoidance conflicts showed that animals and humans start to oscillate behaviorally between two aversive situations when avoidance of one aversive situation results in the exposure to the other aversive situation (e.g. Boyd, Robinson, & Fetterman, 2011; Hovland & Sears, 1938). An avoidance-avoidance conflict may also apply to the present task setup in which avoidance of one conflict task resulted in being exposed to another conflict task without viable exit strategy for the participant (except for quitting the experiment). Thus, the aversive experience of a conflict trial may have triggered a transient tendency to avoid the perceived source of the conflict, even when this behavior produced no benefits in the end.

How could such a model be linked to neuromodulatory systems?

A recent model of cognitive control proposed that the conflict signal corresponds with an arousal response of the locus coeruleus-norepinephrine (LC-NE) system (Verguts & Notebaert, 2009). Arousal has been identified as an important neuromodulator for the stability-flexibility trade-off (Aston-Jones & Cohen, 2005; Cohen, McClure, & Angela, 2007). According to adaptive gain theory (Aston-Jones & Cohen, 2005), the phasic mode of the LC-NE arousal response is considered to be responsible for maintaining stability within a task, for instance, when performance spontaneously deteriorates. In contrast, the tonic mode is considered to implement flexibility in switching between different tasks, for instance, when the utility of a task decreases. This distinction between phasic arousal in the service for stable task performance and tonic arousal in the service for flexible task choice corresponds with the present distinction between conflict withdrawal on a task choice level and conflict adjustment on a task performance level.

Chapter 10

Why Reactive Withdrawal is Adaptive

Empirically, the goal of this dissertation was to provide evidence for a reactive accommodative control strategy, a tendency to withdrawal from conflict provoking situations. According to the proposed conflict management framework, conflict strategies are recruited in the service of adaptive behavior. For instance, a proactive assimilation strategy has been related to increased health and subjective well-being (Bandura, 2000; Miller & Wrosch, 2007; Wrosch, Scheier, Miller, et al., 2003). Reactive assimilation as indicated by the Gratton effect has been shown to correlate negatively with depressive symptoms (Clawson et al., 2013) and generalized anxiety disorder related deficits (Larson, Gray, Clayson, Jones, & Kirwan, 2013). Proactive accommodation has been reported to be correlated with self-control success (Hofmann & Kotabe, 2012) and is well established in intervention programs that focus on behavior modification (Aspinwall & Taylor, 1997). Similar, a reactive accommodation control strategy might serve several adaptive functions.

First, a reactive accommodation strategy reduces the need for control. Most conflict situations that require control are not isolated instances but are rather courses of action that expand in time and require multiple consecutive acts of control (cf. Baumeister & Heatherton, 1996). For instance, imagine a typical self-control situation where a person with the goal to stay sober, enters a bar and suddenly is confronted with a tempting drink. One way to overcome this conflict is to withstand the temptation while taking a seat at the bar. Alternatively, after an initial struggle not to immediately order a drink, the person could follow a spontaneous tendency to withdrawal from such a control-demanding situation and leave the bar. One could speculate whether some failures of self-control might be due to a lack of reactive accommodative strategies and thus are the consequence of remaining in the conflict-provoking situation for too long.

Indeed, research on lapse-activated self-control problems suggest that although initial acts of self-control failures are often trivial, they mark the beginning of a more severe breakdown of control (Baumeister & Heatherton, 1996). This abstinence violation effect (Marlatt, 1985; Witkiewitz & Marlatt, 2004) is often observed in addicts who stayed clean of a forbidden substance for a while. These patients respond to an initial consumption of the substance with a cascade of further self-control failures. As stated by Heatherton and Wagner (2011, p. 133): "it is currently not clear, however, how a small indulgence, which itself might not be problematic, escalates into a full-blown binge". Arguably, patients showing lapse activated self-control failures might lack the spontaneous tendency to withdraw from control demanding situations after the initial conflict and therefore indulge in further acts of uncontrolled behavior.

Secondly, withdrawal from conflict might facilitate goal pursuit by enabling a switch from means that afford a high level of control to means that afford fewer demands. Action goals are hierarchically structured (Ondobaka, de Lange, Newman-Norlund, Wiemers, & Bekkering, 2012; Vallacher & Wegner, 1987; Weaver & Arrington, 2013) and can be conceptualized on the level of goals (e.g. I want a coffee) or on the level of means (e.g. I push the green button on the coffee vendor machine). Until now, research on self-control has just started to tackle the question *when* it is, that people decide to use alternative means to achieve a goal (cf. Hofmann, Schmeichel & Baddeley, 2012). For instance, Henderson, Gollwitzer and Oettingen (2007) found that participants who received negative feedback on their task performance were more likely to switch to an alternative strategy, but only when they had formed implementation intentions - if-then plans that specify context variables as release conditions for a specific behavior - to reflect on their strategy use in case of failures (Gollwitzer, 1999).

Finally, when goal pursuit becomes unlikely, it may be necessary to disengage from an unattainable goal (Brandtstädter & Rothermund, 2002; Klinger, 1975; Wrosch, Scheier, Carver, & Schulz, 2003). Research on escalation of commitment (e.g. Brockner, 1992; Staw, 1981) or the sunk cost effect (Arkes & Ayton, 1999) highlights the dramatic consequences to persist with a failing course of action. Unattainable goals and the resulting feelings of frustration and failure may result in psychological distress (Carver & Scheier, 1999). The ability to disengage from these goals has been reported to correlate with subjective well-being, fewer health problems and various physiological markers indicative of stress reactions and responses of the immune system (Miller & Wrosch, 2007; Wrosch, Miller, Scheier, & De Pontet, 2007). Conflict withdrawal might be a candidate mechanism to support adaptive goal disengagement.

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Chapter 11

Conflict Management Strategies in and out of Balance

Although the proposed conflict management framework in its current form does not specify the precise interplay between the stability-flexibility trade-off and the sustained-transient trade-off, a central assumption is that the different strategies need to be kept in balance (cf. Goschke, 2013). Offsetting different constraints allows an agent to optimize the trade-off between different computational demands. For instance, proactive control seems to be the optimal solution for shielding or avoiding distractors, but it comes at a cost. Firstly, proactive control may be implausible in many cases, because it requires highly predictive contextual information (Trommershäuser, Maloney, & Landy, 2008). Secondly, if potential obstacles do not occur, the maintenance of context information in working memory unnecessarily binds capacity that is unavailable for other processes (Braver et al., 2007). However, on the long run stable behavioral patterns allow the gradual acquisition of habits, which then free cognitive capacity.

In contrast, reactive control is more prone to errors because in daily life, fast reactions to distractors are mostly based on underdetermined information (Geng, 2014). Similarly, stability allows an agent to maintain goal directed behavior despite distractions. However, flexibility is essential in response to changing contingencies and for exploration of potentially rewarding courses of action.

Consequently, if the balance between conflict management strategies is distorted, specific patterns of maladaptive behavior are likely. For instance, stability is regarded as a functional response to conflict that helps to maintain intentions active and to pursue goals. However, when control is instigated in abundance or is still kept up even after a goal has been accomplished, stabile behavior may become detrimental. For instance, Koole and colleagues suggested that individuals who exert too much assimilative control sometimes ignore their own needs and desires (Koole, Tops, Strübin, Bouw, Schneider & Jostmann, 2012). More precisely, they reasoned that an ongoing effort to inhibit impulses makes it more difficult to access one´s own negative evaluations of stimuli. Particular strong forms of rigidity can result in a state of perseveration and have been identified as a vulnerability factors for psychological distress and compulsivity (Serpell, Waller, Fearon, & Meyer, 2009). Interestingly, in some obsessive-compulsive disorders, like eating disorders this over-controlled persistence co-occurs with a reduced efficiency in flexibility (Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007).

Contrary to this abundance of stability, other pathologies are prone to an over-regulation of flexibility. For instance, procrastination has been defined as a problem to initiate goal striving (Gollwitzer, Bayer, & McCulloch, 2005; Steel, 2007). Here, proactive accommodative strategies function ineffectively (Ariely & Wertenbroch, 2002). However, everyday observations suggest (cf. Milgram, Sroloff, & Rosenbaum, 1988) that at least some problematic features of procrastination arise because task are started (or only planned), just to be stopped immediately and then to be postponed for a later occasion. Arguably, in these cases the tendency to withdraw from conflict or demand might be too pronounced.

A more general perspective on individual differences is suggested by the action control theory (Kuhl, 1987). According to this detailed analysis of self-regulatory behavior, people react in two distinct ways when confronted with a conflict situation. They either act in a state-oriented manner or in an action-oriented manner (Koole, Jostmann, & Baumann, 2012; Koole, 2004; Kuhl, 1987). State oriented behavior is conceived as a change-preventing mode, characterized by an increased tendency to preserve the current active mental state. In contrast, action orientation is conceived as a change promoting mode that becomes apparent in flexible adaption to current task demands. These constructs reflect chronic dispositions that result from the individual learning history (Koole et al., 2012; Jostmann & Koole, 2007). Several studies have shown that under demanding conditions which require a lot of control, action-oriented participants outperform state-oriented participants (Gröpel, Baumeister, & Beckmann, 2014; Kuhl & Beckmann, 1994). Further research could address whether these differences reflect a general advantage for action-oriented individuals in all conflict management strategies, whether these personality traits affect conflict management strategies differently or whether they influence the balance between the different conflict strategies. Certainly, before generalizing the present findings to an inter-individual perspective, a careful analysis of intra-individual variations of conflict management strategies is necessary.

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Chapter 12

A New Look on Self-Control Failures

When control was not successful, people sometimes act against their own goals and give in to unwanted urges or habits. By dissecting out different strategies to deal with conflict, the conflict management account suggests a new look on self-control failures. According to an influential analysis of self-control failures by Baumeister and colleagues (Baumeister et al., 1994; see also Baumeister & Heathertone, 1996) self-control failures can be differentiated according to two types. On the one hand, *under-regulation* refers to a failure to engage in self-control in the first place. Under-regulation can result from problems in motivation, monitoring or ambiguous standards. On the other hand, *miss-regulation* entails that control is exerted over one´s behavior, but this control is unsuccessful. Baumeister and colleagues identified three causes for miss-regulation. Firstly, miss-regulation can be the results of false assumptions about perceived contingencies between ones´ own action and the produced outcome. More broadly, the first case of miss-regulation has been interpreted to exhibit a lack of self-knowledge (Baumeister et al., 1994). Secondly, miss-regulation can be the consequences of an unrealistic believe of control. Irrational control assumptions cause people to spend effort on tasks that are inherently not controllable. And thirdly, people show miss-regulation because they focus on the wrong aspects of a self-control dilemma (Baumeister et al., 1994).

The present analysis suggests a more mechanistic view of miss-regulation failures. According to the conflict management framework, miss-regulation occurs because the selection and implementation of conflict strategies is defective. Inappropriate usage of strategies can result from (1) personal factors that cause a chronic imbalance of strategies (see Chapter 11) or it can result from (2) situational factors that constrain the expression of a particular strategy. For instance, one of the most prominent paradigms employed to study self-control is the so-called depletion paradigm. In this procedure, participants work through two different tasks in sequence. Critically, for the experimental group the first task is demanding and taxes self-control resources. However, for a control group, the first task is not demanding and self-control resources are unaffected. After the initial task, participants are asked to perform another unrelated task that probes control capacity. A study by Inzlicht and Gutsell (2007) illustrates a typical example of this design. As a first task participants had to suppress their emotions during a film. As a second subsequent task, they had to perform a Stroop task. A consistent finding in this and other studies was that participants who performed the demanding variant of task 1 showed a deterioration in performance during task 2 (e.g. increased interference in Stroop task) compared to the control group (see Hagger, Wood, Stiff, & Chatzisarantis, 2010 for a meta-analysis). According to the prevailing interpretation of the ego-depletion effect, these findings are supposed to show that control resources are task general and capacity-limited. Thus, a demanding task 1 reduces the available capacity for the subsequent task 2, giving rise to the so-called depletion effect (Baumeister & Vohs, 2007; Muraven & Baumeister, 2000; Muraven & Slessareva, 2003).

Recently, this interpretation has been questioned both on theoretical (Inzlicht, Schmeichel, & Macrae, 2014; Inzlicht & Schmeichel, 2012; see also Navon, 1984 for a general critique of resource models) and empirical grounds (Job, Dweck, & Walton, 2010; Muraven & Slessareva, 2003). In line with this critique, the conflict management framework suggests an alternative interpretation of the depletion effect. Arguably, enduring performance in the ´depleting´ task 1 is achieved by a proactive control mode (e.g. suppressing of one's´ emotion during a stressful video clip). When participants change to the subsequent task 2, the context that was harnessed to guide control in task 1 is no longer appropriate. Thus proactive control comes at the cost of inertia of control settings. Consequently performance in task 2 is impaired. In line with this assumption, Dewitte, Bruyneel and Geyskens (2009) observed that only task 1-task 2 sequences with different control demands show detrimental effects on task 2 performance, whereas identical control demands in task 1-task 2 sequences actually improve performance in task 2. Clearly, this is evidence for a prolonged activation of the same proactive control mode in both tasks. In contrast, in the non-depletion group very little control is needed to perform task 1. Hence, performance in task 2 is less impaired by a carry-over of control settings. Future research should test this alternative explanation of the depletion effect more systematically by using different tasks that allow a carry-over of proactive control settings from one task to another.

Concluding Remarks

Conflict is ubiquitous and comes in many different ways. Not surprisingly, the means to control conflicts are diverse, too. The present thesis proposed a framework that describes different conflict management strategies and thereby allows a classification of the variability of control. This classification of different conflict strategies and the corresponding behavioral markers to probe these strategies open up the opportunity to investigate how different conflict strategies are gauged and integrated. Empirically, dissociative and correlative approaches could specify to which extend various conflict strategies rely on similar or distinct mechanisms. Furthermore, careful modeling of empirical findings could provide detailed accounts how the interaction of seemingly opposing conflict strategies are implemented. Clearly, from the present work it is a long way towards a unified theory of control. Until then, focusing on some parts of control (i.e. strategies) might be worthwhile.

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