Article in press

An Integrative Framework of Conflict and Control

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Keywords: cognitive control; conflict; conflict resolution; self-control; moral decision making; complexity

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Abstract

People regularly encounter various types of conflict. Here, we ask if—and, if so, how—different types of conflict, from lab-based Stroop conflicts to everyday-life self-control or moral conflicts, are related to one other. We present a framework that assumes that action–goal representations are hierarchically organized, ranging from concrete actions to abstract goals. The framework's key assumption is that conflicts involving more abstract goals (e.g., self-control/moral conflict) are embedded in a more complex action space; thus, to resolve such conflicts, people need to consider more associated goals and actions. We discuss how differences in complexity impact conflict resolution mechanisms and the costs/benefits of resolving conflicts. Altogether, we offer a new way to conceptualize and analyze conflict regulation across different domains.

Are All Conflicts the Same?

Are all **conflicts** (see Glossary), in essence, the same? In the **trolley dilemma**, traditionally used to study moral conflicts, people choose whether or not to sacrifice one person to save many. During **intertemporal choice**, traditionally used to study self-control conflicts, people decide between smaller immediate and larger delayed rewards. In the **Stroop task**, traditionally used to study cognitive conflicts, people distinguish between relevant and irrelevant information. If these conflicts are entirely different, psychological science would need distinct theories to account for each of them. However, if they are sufficiently similar, capturing them in a single framework could inspire the development of a comprehensive theory of human action.

On the one hand, it makes intuitive sense to argue for the similarity of different types of conflict, as they all share the same underlying structure: they involve some form of incongruency that needs to be resolved (Box 1). Also, across various research domains, the process of **conflict resolution** has been conceptualized similarly, as a two-step process (first detecting the conflict, then exerting control [1–3]). On the other hand, the differences between different types of conflict are too glaring to ignore. Some conflicts require people to consider only a few concrete actions (e.g., a single task rule); whereas others require people to consider multiple actions and more abstract goals (e.g., potential consequences, personal preferences). Similarly, some conflicts take milliseconds to resolve; others days or weeks.

Empirically, this controversy is illustrated by findings showing that laboratory-based conflict tasks sometimes do [4] and sometimes do not relate to outcomes of real-life conflict [5–7]. Recent attempts to settle this inconsistency pointed towards problems with methods and measurement [8–12]. In this paper, we argue that the problem runs deeper. We propose that conflict research faces a problem with theory. In support of our argument, we first elaborate on two fundamental differences between conflicts that we believe have posed challenges to theoretical integration so far. Moving forward, we propose a new framework that rests on four propositions which integrate both challenges in a meaningful way. The framework provides a common language allowing researchers across domains in psychology and neuroscience to relate different kinds of conflict to each other. Beyond its potential to explain existing research within a shared perspective, the framework generates new predictions and sets an agenda for future research on conflict regulation.

The Vertical Challenge: What Conflicts are Made of

Conflict is a central motif in psychology and has always spurred crosstalk between different disciplines. For example, early ideas from information theory (about conflict in the context of curiosity [13]) both motivated cognitive dissonance theory in social psychology [14] and inspired computational models in cognitive neuroscience [1]. Exchange is also common on the methodological level: Originally developed as a cognitive paradigm to assess attentional filtering, the Stroop task has been applied in research programs to study conflicts in self-control [7,15,16], psychopathology [17], stereotyping [18], social power [19], romantic relationships [20], and personality [21]. Recently, researchers have realized that theories and paradigms need to be integrated more thoroughly, asking whether there is some cognitive or neural mechanism that is common to all conflicts [22,23]. For example, it has been proposed that all conflicts are tied to negative affect [24–30], or involve expectancy violations [31]. From that, it seems that there is an emerging consensus that all conflicts are similar enough to be captured by a single model.

Despite this consensus, conflicts differ widely in terms of the nature and scope of their components. Some conflicts (e.g., resolving a Stroop trial) require people to consider just one concrete action plan, whereas other conflicts (e.g., deciding to quit one’s job in order to travel the world) require people to simultaneously consider a greater number and often more abstract aspects of goals (e.g., current needs, potential consequences, relative value of the options). Yet, how these conflicts can be mapped to each other is still poorly understood across literatures. We term this problem the *vertical challenge* and we use this term to describe the difficulty to relate conflicts across different levels of a hierarchy.

The Horizontal Challenge: When are Conflicts Resolved

Trying to understand how people resolve conflicts, most theories propose some variant of a two-step process, in which conflict is first detected and then resolved [1–3,25,32,33]. For example, cognitive neuroscience accounts [1] describe a monitoring mechanism that triggers conflict resolution by biasing attention toward task-relevant features. In line with this model, imaging studies show dissociable neural activity in the anterior cingulate cortex (occurring when conflict is detected) vs. the dorsolateral prefrontal cortex (occurring when task-relevant attention is boosted [34,35]). Such a two-step process is also inherent to cybernetic models of self-regulation, which assume a monitoring system that compares desired and actual goal states, and an implementing system aiming to reduce potential discrepancies [32]. Similar two-step models explain conflict resolution in various other domains, like self-control [2,36], emotion regulation [37], moral decision making [38], and knowledge acquisition [39].

Yet, despite these commonalities, there are glaring differences between domains in the temporal extension of conflict resolution. To illustrate, we compare a conflict in the Stroop task with a conflict between two food options—say, between eating salad or pizza for dinner. Conflict in the Stroop task is resolved by deploying attention to task-relevant stimulus features. However, when deciding between food options, people use qualitatively different and temporally more protracted strategies. For instance, the process model of self-control

[40] assumes that conflict regulation can be subdivided into different stages, with attention deployment being only one way to regulate conflict. Other ways, like changing the situation (e.g., avoiding the pizza restaurant), can prevent conflict from occurring in the first place. And, when it is too late to avoid the conflict, people can still actively reappraise the situation (e.g., how much they deserved treating themselves to pizza). Importantly, these strategies can come into play at different points in time for different conflicts. We refer to this as the *horizontal challenge*, which pertains to the differences in temporal space in which control is recruited.

Proposing an Integrative Framework of Conflict and Control

It is difficult to overstate the relevance of the vertical and horizontal challenges for conflict researchers. This becomes apparent when we consider the *correlational approach*, the most-used research strategy to assess how conflicts and control of conflicts are related across domains. In this approach, researchers assess participants´ responses to conflict at different levels of analysis, testing the same participants in different conflict tasks. If, for example, conflict resolution in the Stroop task covaries with people's efficacy to resolve self-control or moral conflicts in the lab, or even in real life, this would indicate that a direct mapping of conflict and control across domains is feasible [41,42]. However, findings obtained with this approach have been mixed, with many studies reporting no or only very weak associations [5–7,43].

We argue that the problem conflict researchers are facing is a more fundamental one. If we want to better understand how conflict and control can be linked across domains, we must explain the variability people show in their attempts to control conflict on multiple levels and across time. We present an integrative framework that captures the challenges portrayed above. It outlines four basic propositions that describe conflict and conflict resolution through a hierarchical organization of action-goal representations. By doing so, it suggests that the vertical and horizontal challenge are not independent, but rather that one follows from the other. The framework has implications for our understanding of conflict regulation and allows researchers to draw meaningful links between different levels of analysis and research traditions.

Proposition 1. Action and Goal Representations are Hierarchically Organized

We draw from models of action control that posit that **action representations** are hierarchically organized; more abstract action representations (or **goal representations**) activate increasingly more concrete action representations, and ultimately, actions [44–46]. Our framework captures this assumption in the hierarchical organization of nodes representing specific actions at the lowest level, up to abstract goals at the highest level (Figure 1, Panel A). The bottom (lowest) level consists of concrete action representations ("press button A" or "order the pizza"). Moving up the hierarchy, nodes refer to goal representations ("follow the instructions" or "get tasty food") and these representations become increasingly more abstract higher up in the hierarchy ("enjoy oneself" is a more abstract goal than "get tasty food"). Notably, conflicts can occur on every level of the action-goal hierarchy, both between representations at the same level and between representations at different levels.

Proposition 2. Action Representations are at the Heart of all Conflicts

Conflict and conflict resolution are ultimately action-oriented. This proposition is grounded in research suggesting that all representations, even abstract ones, are anchored in actions [45,47]. In our framework, this implies a bi-directional flow of information. This means that (a) lower-level conflict can escalate to higher-level goals (e.g., besides executing the task rule, resolving a response conflict in the Stroop task may also involve the more abstract goal to perform well or to earn money; Figure 1, Panel B), (b) that conflicts between higher-level goals always imply conflicts at the action level, either real or hypothetical (e.g., pulling vs. not pulling the lever in a trolley dilemma), and (c) that conflict resolution engenders changes on lower levels until the action is performed (Figure 1, Panel C). Importantly, this means that a seemingly identical action conflict (e.g., whether to grab the car or bike keys; see Figure 2, Panel B) can be represented at different levels of abstraction (e.g., saving time vs. saving resources or being a good parent vs. a good person).

Proposition 3. More Abstract Goals are Embedded in a More Complex Action Space

The more abstract the goal representation, the further away it is from a specific action [44,45]. This is in part because abstract representations contain the gist of things rather than details [48], but also because there are simply more means available to achieve an abstract goal (e.g., to pursue good health, one could eat healthy food, exercise more, or try to sleep better). Abstract goals thus entail a larger number of links between goals, sub-goals, means and actions. Resolving conflicts at the level of more abstract goals, therefore, implies a larger number of possible sub-goals and actions being activated. Thus, abstract and concrete representations entail different levels of **complexity**. To define complexity, we take inspiration from information-theoretic approaches that define complexity in terms of the amount of information required to describe the conflict (i.e., description length) [13]. This is similar to the concept of policy complexity [49,50]. In the proposed framework, this amount of information depends on the number of connections between different nodes within the network (i.e., superordinate goals, goals and actions; see Proposition 2). Thus, the amount of information in the hierarchical structure of our framework approximates complexity and can be used to scale goals and actions in a meaningful way. Accordingly, conflicts higher up the hierarchy take more space in the diagram as they include more associated subgoals and actions than conflicts at lower levels (Figure 2, Panel A, Row 1-3).

Proposition 4. Conflict Between Increasingly Abstract Goals Extends Over Time

Let us revisit some typical examples of conflict (Figure 2, Panel C Row 1-3). In the Stroop task, conflict arises between concrete actions (response triggered by automatic word reading and response rule). In line with our framework, this low-level conflict comes with a rather narrow time scale, as research on the Stroop task is mostly concerned with conflict resolution within a single trial or shortly before or after the trial [51]. In a self-control conflict task, conflict arises between, for example, the goal to stay healthy and the desire to eat pizza. In a moral conflict, deontological and utilitarian principles compete with one another. To describe each of these conflicts, we need to move up the goal hierarchy. Because goals higher in the hierarchy are more complex (e.g., the number of considerations and actions to achieve these goals is higher), there are more possibilities to intervene, and people have a broader repertoire of control strategies at their disposal. For instance, before a conflict, a person might anticipate a possible conflict and avoid exposure to tempting stimuli in advance. Alternatively, following a conflict, a person might re-evaluate experienced conflict differently by appraising a situation as a possibility to indulge oneself. Thus, conflicts at high levels of abstraction do not only occupy a larger action space (see Proposition 3), but they also occupy a more prolonged *temporal* space during which different forms of control can be employed (see funnel shape in Figure 1, Panel D).

Implications

Our framework proposes that the difference between conflicts can best be understood along the dimension of complexity. It suggests that the vertical and horizontal challenge are closely related: because more complex conflicts are embedded in a larger action space, they allow for more diverse control strategies and, thus, conflict resolution extends longer in time. Our conceptualization has key implications for models of conflict resolution. In the next part, building on insights from different research areas, we will illustrate how differences in complexity affect mechanisms by which people resolve conflict, we reflect on how conflict resolution mandates a trade-off between costs and benefits, and we propose an agenda for future research.

Hierarchy Determines Conflict Resolution

Self-control researchers have debated what mechanisms underlie conflict resolution [52–54]. Some researchers argue that control reflects the inhibition of automatic response tendencies [52]; others argue that self-control can best be understood as a dynamic decision-making process in which different options are weighed [53]. Our framework has the potential to resolve this debate, by suggesting that the two perspectives describe conflict resolution at different levels of abstraction. This idea is consistent with existing accounts of a hierarchical organization of control processes in the frontal cortex [55]. At lower levels of abstraction, control requires people to consider fewer and more concrete goals and actions (Proposition 3). Hence, resolution of simple conflicts, as investigated with the Stroop task, can be described as the inhibition of an inappropriate action (e.g., ‘to grab the car keys’ needs to be inhibited when people form the intention ‘to take the bike today’; Figure 2, Panel B, Row 1). Here, control ensures the correct response within the context of a specific rule. By contrast, conflict regulation at higher levels of abstraction resembles a multi-stage decision-making process (e.g., people oscillate between ‘to save time’ and ‘to act environmentally friendly’; Figure 2, Panel B, Row 2), which requires people to simulate and evaluate various actions and their potential consequences [56–59]. In such situations, there is room for a variety of control processes to take place (e.g., attention deployment, appraisal [60]). Here, control serves to ensure conflict resolution, per se, namely, resolving the conflict rather than deferring the decision. This way, our framework offers a big-picture perspective on the contrasting ways in which self-control is currently being conceptualized (Box 2).

The empirical finding that correlations between different conflict measures are often low was previously considered surprising. By contrast, our framework suggests that these correlations should be expected to be low. That is, at different levels of complexity, conflict measures tap into different action representations, which require different forms of conflict resolution. Relatedly, because more complex conflicts extend longer in time, they allow for more diverse control strategies (Proposition 4). Thus, it is unrealistic to expect that the way people resolve low-complexity conflicts is directly related to how people resolve high-complexity conflicts. However, our framework could guide future work that aims to optimize the correlational approach. It may be possible to accurately predict how people resolve real-life conflicts from lab-based tasks if measures are more aligned on action abstraction (ranging from concrete response rules to more abstract decision making) and strategy selection (ranging from earlier anticipatory to later corrective strategies;[40,51]).

The Costs of Going up the Hierarchy

Why is it that people often fail to consider their higher-level goals [61]? According to Proposition 3, moving up the **goal hierarchy** implies representing (and simulating) an increasing number of actions and their consequences. Given the embodied nature of action planning and action simulations (Proposition 2), these processes require time and cognitive resources [62]. That is, not only do more abstract goal representations come with more connections to other nodes in the network, but the neural representations that are involved are also more likely to overlap with neural representations related to competing goals, increasing the opportunities for interference [63,64]. Moreover, resolving conflicts at a higher level of abstraction will be accompanied by a stronger sense of uncertainty. Since abstract conflicts involve the consideration and evaluation of an increasing amount of information (Proposition 3), uncertainty increases about which action is the ‘correct’ one (e.g., “Is it more important to spend time with my family than it is to be a good example and act in an environmentally friendly way?“), and uncertainty about whether a specific action leads to the desired outcome (e.g., “Does taking the bike really help save the planet?”). For both reasons (increase representational overlap and uncertainty), we argue that conflict resolution at higher levels should generally be more costly. As a consequence, we predict that, all else being equal, people should have a general preference to resolve conflicts at lower levels of the action–goal hierarchy [44] and to avoid higher level conflict resolution [62].

A further benefit of resolving conflict on lower, rather than higher, levels of abstraction it is that this may support behavioral consistency (i.e., enacting the exact same behavior in the same or similar contexts in the future). There has been much interest in the effect of conflict resolution on future behavior across domains (e.g., congruency sequence effect, sustained self-control behavior). One common assumption is that conflict can function as a learning signal reinforcing active representations [3,65]. Without acknowledging the hierarchical organization of action-goal representations, however, any model assuming the common two-step control process will come to the similar conclusion that conflict will reinforce whatever representation drove the action (e.g., task rule, health goal, moral value), with more consistent future behavior as a result. Our framework, however, suggests that complexity matters. Specifically, it predicts that conflict complexity should modulate learning. Given that conflicts higher up the hierarchy include more associated subgoals and actions (Proposition 3), we expect that the reinforcement signal should spread across multiple nodes rather than just one. In line with goal system theory, and general spreading activation accounts, which posit that the strength of the activation decays as it propagates through the network [46], [64] we propose that the link between the enacted behavior and the reinforced goal should thus be weaker the more abstract the goal is (and stronger for more concrete action plans or goals). As a consequence, high level conflicts should be followed by relatively less behavioral consistency [66]. This effect may be compounded by the fact that single actions almost never immediately satisfy abstract goals, which means that the learning signal is delayed and thus weaker to begin with [67].

By contrast, when conflicts are solved at a low level, a concrete task rule is enacted and reinforced, which should readily strengthen behavioral consistency. This prediction resonates with research showing that behavioral interventions that require the implementation or monitoring of concrete actions are often effective (e.g., in the context of health behavior [68]; in the context of psychotherapy, [69]). Possibly, these interventions reduce complexity by limiting possible connections between goals and actions (Proposition 3). In turn, this may reduce opportunity costs, uncertainty, and regret [29,70]. An important question for future research is how people can become more confident about resolving ~~high-complexity~~abstract conflicts, as this might be a way to achieve behavioral consistency nonetheless. Prior work suggests that giving more weight to the action-congruent, but not the action-incongruent, goal can boost confidence (e.g., 'to save resources' and not 'to save time' in case one chooses to take the bike; [71]). Our framework adds that this intervention should be especially useful in the context of ~~high-complexity~~abstract conflicts, because there confidence is potentially lower. Perhaps, this can be achieved by explicitly guiding people's attention to the action-congruent goal or providing positive feedback.

The Benefits of Going up the Hierarchy

If resolving conflict on the level of abstract goals comes with costs, why should people escalate to this level at all? Our framework predicts that higher level conflict resolution has the potential to influence behavior across contexts and on the long-term. First, we note that even small amounts of activation can strengthen a goal when repeated over time. For example, a person's health goals will never get reinforced if they always solve food conflicts at a low level ("I eat salad today because it is salad day"). Yet, their health goal will get reinforced, at least sometimes, if they sometimes resolve food conflicts at a high level ("I eat salad today because I find a healthy lifestyle important"). Given people's general tendency to solve conflicts at lower levels, our framework explains why people find it difficult to act in line with their goals in new situations. Second, as ~~higher level~~abstract goals are mapped onto more subgoals, our framework predicts that there should also be more generalization across behaviors that serve the same goal when conflicts are resolved at a higher level (e.g., repeatedly choosing the bike for environmental reasons should increase likelihood of buying a vegetarian meal). Such generalizability is particularly useful for the pursuit of more abstract goals, as these can only be achieved through repeatedly engaging in a variety of goal-conducive actions over time.

A final benefit from resolving conflict at higher levels stems from the observation that abstract goals are often core goals—i.e., goals that are intertwined with people's identity [44,72]. Thus, resolving conflicts at higher levels of abstraction may be important for people's self-concept and for experiencing actions as meaningful [73]. That is, we predict that, over time, resolving conflicts at a higher level may produce a broad and diverse, yet identity-congruent behavioral pattern [74]. The enhanced impact over time with increasing levels of complexity is captured in the funnel shape in Figure 1 D. In sum, drawing from our framework, we posit that resolving conflict at higher levels has costs (e.g., increasing computational costs and uncertainty), but also unique benefits (e.g., generalization and identity shaping).

Research Agenda

Computational models of control and decision-making suggest that behavior follows from a cost–benefit trade off, in which people weigh anticipated costs against potential rewards [75]. Although these models can successfully describe behavior, it often remains unclear why control of some conflicts is more costly than the control of others. Our framework provides a potential answer to this question: we propose that complexity—represented as the amount of information or number of possible connections in the network—should scale with processing costs of going up the hierarchy (i.e., increasing abstractness of the active representations; Proposition 3). This form of meta-control [76,77] can, therefore, be conceptualized as a decision about the level of abstraction (and thus complexity) at which conflicts are resolved. Based on this novel perspective, future computational work could arrive at an account of hierarchical conflict control, by juxtaposing the costs and benefits of complexity.

More broadly, our framework can serve as a starting point for an interdisciplinary, systematic, experimental approach of studying conflict regulation in different domains. Concretely, our framework suggests that we need new experimental paradigms, which allow for the manipulation and measurement of conflicts of varying complexity. A first step is to examine how conflict complexity can be captured in reaction times [78], different types of errors [79], and behavioral and (neuro)physiological indicators [80,81]. For example, more complex conflict stimuli should produce longer reaction times than stimuli of lower complexity in the same task. Relatedly, since more compared to less complex conflict resolution may involve the use of different strategies, it is necessary to attempt to assess multiple control strategies within the same task [82]. One could also investigate variation in subjective conflict complexity through assessing its determinants (e.g., number of considered goals or actions) or its consequences (e.g., amount of strategies used, uncertainty about correct response, outcome uncertainty, experience of effort) via self-report [83,84].

A second step is to manipulate the complexity of conflicts [62,78]. For example, a recent study manipulated ‘policy abstraction’ in a cognitive control task by varying the amount of contextual contingencies of the task rule (one symbol determines response vs. two or more symbols jointly determine response [62]). In line with what our framework would predict, they show that participants avoided higher policy abstraction tasks more often. Building on those initial efforts, future research requires experimental paradigms that allow a systematic and equivalent mapping of complexity across different research traditions. We, therefore, recommend building hybrid paradigms that allow for different types of conflict (e.g., typical response conflicts, self-control conflicts, and moral conflicts) within the same task or design space [85]. For example, one could think of designing a task in which an agent has to make consecutive decisions that vary in conflict complexity: delivering packages across the city and encountering low complexity conflicts (e.g., following instructions of traffic agent vs. traffic lights) and high complexity conflicts (e.g., picking mode of transportation: environmentally friendly bike vs. more efficient car). Finally, it is necessary to combine both measurement and manipulation of conflict and complexity because conflict representations vary depending on person and situation. For example, contextual factors such as fatigue may reduce people’s willingness to invest the higher costs of moving up the hierarchy [86]. Similarly, individual differences such as trait self-control or need for cognition may impact at what level people represent the conflict and their choice of conflict resolution strategies [60,87,88].

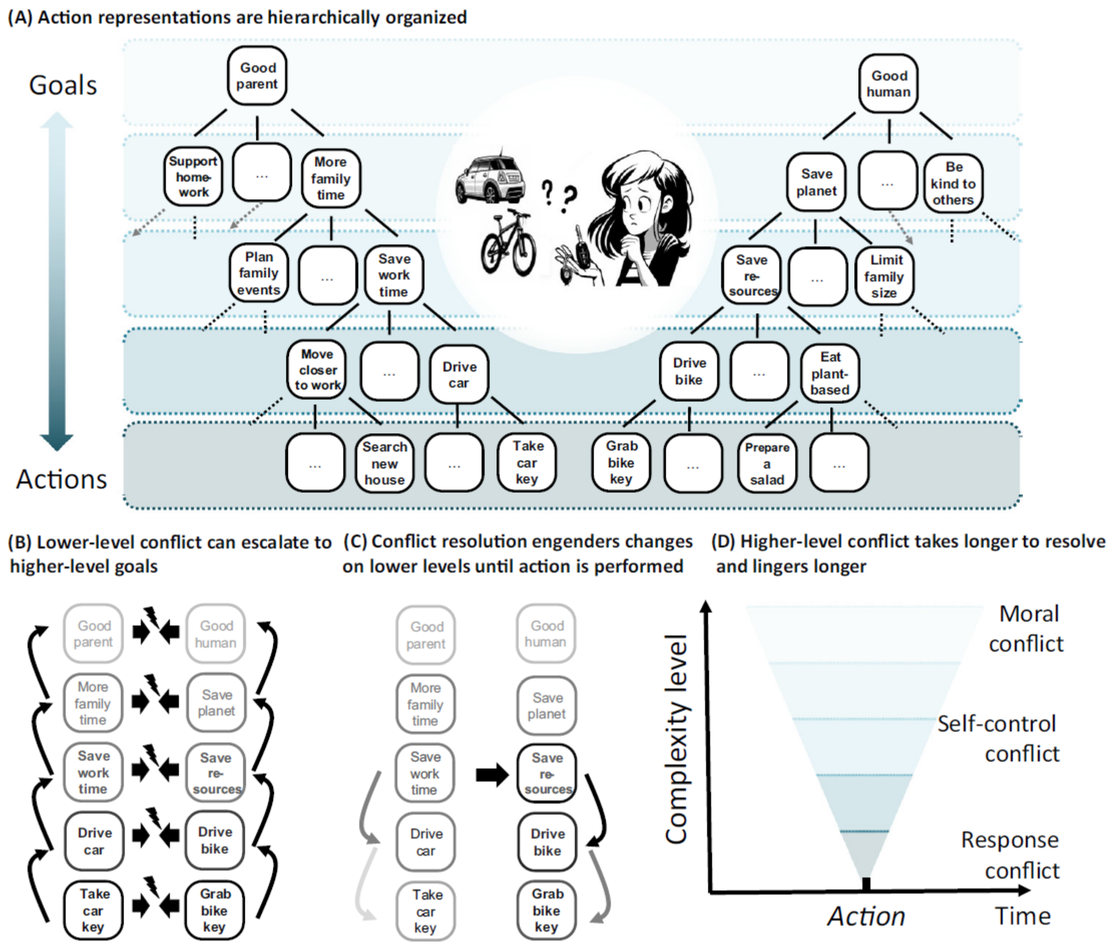
Concluding Remarks

For decades, researchers have been concerned with the question of whether 'all conflicts are the same'. Here, we present an integrative framework that proposes that different conflicts vary along the dimension of complexity. The framework captures the similarities and differences between different conflicts and provides a unifying language and conceptual frame that allows researchers across domains to relate different kinds of conflict to each other. Although many open questions remain (see Outstanding Questions), the framework explains existing phenomena and disparities in the literature and offers novel insights and predictions, yielding a new agenda for research on conflict regulation across different domains.

Figure Titles/Legends

Figure 1

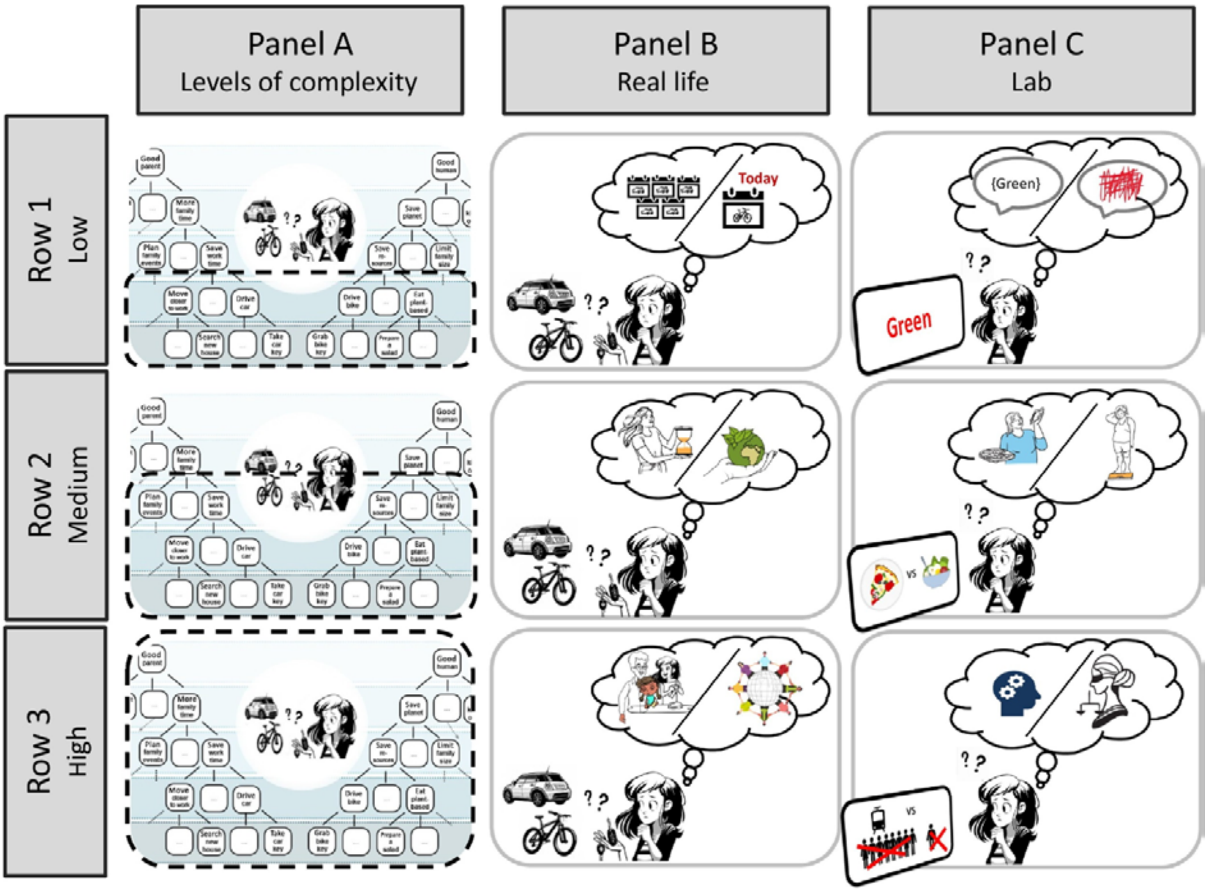
Schematic Representations of the Integrative Framework of Conflict Regulation



Note. Panel A shows the hierarchical organization of action/goal representations, with concrete action representations (darker shade of grey) at the bottom layer and increasingly abstract goal representations towards the top layer (lighter shades of grey). Boxes represent nodes, which represent specific actions or goals. Paths depict bi-directional activations between nodes. Panel B shows that lower level action conflicts can trigger higher level goal conflicts. Panel C shows that when the conflict is resolved by changing the representational strengths of a higher-level goal representation (e.g., commit to saving natural resources), this will engender changes on lower levels until an action is performed (e.g., grab bike key). Panel D shows that both challenges are not independent: Conflicts of higher complexity (represented at higher levels of abstraction) do not only occupy a larger action space, but they also occupy a more prolonged temporal space and more diverse resolution strategies. Time on the horizontal axis represents the duration (i.e., temporal space) of conflict regulation.

Figure 2

Conflicts at Different Levels of Complexity



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Boxes

BOX 1: What is conflict? Energy versus entropy

Conflict arises whenever there are incongruent thoughts or action tendencies. But what does conflict mean in mechanistic terms? An intuitive proposal is to express conflict as the proportion of incongruent cognitive processes—thoughts, perceptions, action tendencies—relative to all ongoing cognitive operations [14,89]. However, research suggests that conflict can be parsed into separable components, e.g., response-conflict vs. stimulus-conflict [90]. An influential idea that allows for separate classes of conflict comes from neural network models [1], which propose that neural networks consist of different layers that house, for example, stimulus or response units. Conflict arises whenever multiple units within the same layer are active simultaneously. The degree of conflict, then, is defined as the (scaled) multiplicative product of their activation level, which is known as *Hopfield energy* [1,91]. The strength and the time course of conflict thus follow directly from the activation of computing units, scaled by the strength of mutual lateral inhibition.

One limitation of conceptualizing conflict in terms of parallel activation of stimulus and response representations with a defined task with known goal-action links (e.g., Stroop) is that it cannot account for abstract representations of upcoming situations or future goals that are more uncertain in nature. So, the conceptualization of conflict as energy needs to be extended to incorporate predictions and their corresponding uncertainty. In computational terms, conflict also entails *entropy*, i.e., unpredictability [13], with conflict increasing with the complexity of the situation.

Here we propose to see these two views of conflict as complementary rather than competing. For instance, the concept of conflict-as-energy is relevant to describe pursuit of currently active goals, while conflict-as-entropy can capture the process of choosing a future goal among multiple alternatives.

BOX 2: Reconciling current debates on conflict and control

Dual- vs. single-process

Traditionally, control has been type-cast as the antagonist to automatic and impulsive tendencies. Dual-process models capture this idea by construing control as a slow and deliberate process that inhibits fast and automatic impulses. This view has been challenged by single-process models which describe control as a value-based choice that weighs actions according to their costs and the benefits of potential outcomes [53]. Recently, similar debates in different domains (e.g., self-control) have focused on differences in assumed mechanisms. Our framework can reconcile this debate by showing that the two perspectives describe conflict resolution at different levels of complexity (Proposition 3).

Unitary vs. fractioned control

Our framework also contributes to a debate asking whether control is due to a single controller (i.e., the unitary hypothesis) or is the consequence of multiple, independent controllers. For example, personality research asks whether different conflict tasks can be explained by a few latent variables [92]. Neuroscientists debate whether prefrontal areas reflect a core network for control or local individual controllers [93]. Cognitive science discusses whether control processes can generalize across tasks or operate task-specific [94]; and developmental science tests whether training of control transfers to other tasks or not [95]. Here, we propose that while basic aspects of conflict processing are shared across tasks, the fractioning depends on the complexity (with more abstract conflicts allowing for broader control strategies, Proposition 4) and the specifics how actions are implemented (Proposition

2). Our framework also suggests when research should expect to find evidence for the unitary view (e.g. when measures are aligned along the horizontal axis) and when to expect evidence for the fractioned view (e.g., when measures do not align).

Weakness of will vs. goal inconsistency

Finally, self-control failures have often been conceptualized as a weakness of the will in which impulses overrule intended behavior. An alternative conception considers conflicts as a (temporal) inconsistency of different goals [96]. From this perspective, a failure of control reflects a change in the importance of goals, either because a temporally more distant goal is discounted or because a goal that promises immediate reward (i.e., hedonic goal) becomes self-relevant (e.g., sharing pizza because you celebrate a special occasion with friends; [97,98]. Our framework captures both perspectives. Conflict between more abstract goals provides a description of goal-inconsistency (Proposition 3), whereas conflict at concrete levels refer to situations in which specific action impulses overrule goals or intentions.

Glossary

Complexity: Refers to the number of connections within the network (e.g., during planning, simulation, evaluation, consideration and adjustment of possible action plans and their consequences). In the goal hierarchy, more abstract goal representations are embedded in a broader action space, because of the larger number of links between goals and sub-goals, means and actions (cf. goal hierarchy).

Conflict: Occurs when two or more mutually incompatible goal and/or action representations are active at any level or between levels of the goal hierarchy.

Conflict resolution: Processes involved in implementing actions, changing goal representations, and/or revising the goal hierarchy to end the conflict experience. Conflict resolution can be fast, but can also protract over time.

Goal hierarchy: Describes the relationship of different goal and action representations in a spatial arrangement, with more abstract goal representations higher up in the hierarchy and concrete action representations at the bottom. Moving up the hierarchy (i.e., increasing abstractness) means that goal representations entail an increasing number of subgoal and action representations (i.e., cover more action space), implying a greater number of possibilities for intervention (cf. complexity).

Goal/Action representations: A hypothetical construct within cognitive processing that represents personal goals, values, and the like (i.e., higher-level goal representations) as well as the perception of the end state or result of a concrete (motor) action (i.e., low-level action representation). Goal and action representations are interlinked in a larger associative network, which is often depicted in the form of nodes (goal/action representations) and lines (associations).

Intertemporal choice: A classic self-control conflict between a smaller, immediately available reward and a larger, delayed reward, where the subjective value of the later reward is devalued because it is further in the future.

Stroop task: A classic experimental paradigm used to study cognitive conflict. Participants are asked to name the ink color of a color word while ignoring the meaning of the word. Word color and meaning can either match or mismatch. In the latter case, participants experience conflict between the instructed response goal (name the ink color) and the response tendency triggered by automatic word reading.

Trolley dilemma: A classic moral dilemma about whether or not to sacrifice one person to save many, used to study moral conflicts. It describes the scenario of a runaway train about to kill several people on the tracks. Participants are asked to identify with a bystander who can divert the train to another track but would thereby kill another person. In contrast to (norm-oriented) deontology, (outcome-oriented) utilitarianism regards the sacrifice as required.

Acknowledgements

The ideas presented in this paper were collaboratively developed by all contributing authors within the Scientific Network on Conflict Regulation, supported by the German Research Foundation. Special appreciation is extended to Elena Frei for her invaluable assistance in coordinating multiple in-person meetings for this Scientific Network in Tübingen.

Preparation and writing of this article were funded by a “Scientific Network” grant from the German Research Foundation awarded to DD (DI 2126/5-1). DB is funded by NWO XS (406.XS.01.150). DD acknowledges support by grant Di 2123/3-2 from the German Research Foundation. RP is funded in the Heisenberg Programme of the German Research Foundation (PF 853/10-1). AMFR acknowledges support by grants from the German Research Foundation (DFG RE 4449/1-1,SFB 940/3, B7 RTG 2660/B2) and by a 2020 NARSAD Young Investigator Grant. AS received an Emmy Noether fellowship from the German Research Foundation (SO 1636/2-1). SB is funded by an ERC Starting grant (852570).

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