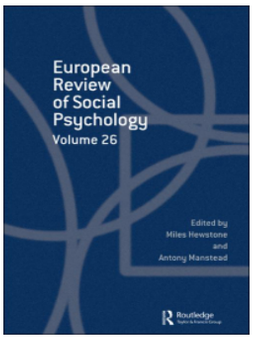

European Review of Social Psychology

ISSN: 1046-3283 (Print) 1479-277X (Online) Journal homepage: www.tandfonline.com/journals/pers20

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To cite this article: Maik Bieleke, Lucas Keller & Peter M. Gollwitzer (2021) If-then planning, European Review of Social Psychology, 32:1, 88-122, DOI: 10.1080/10463283.2020.1808936

To link to this article: https://doi.org/10.1080/10463283.2020.1808936

Published online: 10 Dec 2020.

EUROPEAN REVIEW OF SOCIAL PSYCHOLOGY
2021, VOL. 32, NO. 1, 88–122
https://doi.org/10.1080/10463283.2020.1808936

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ARTICLE

If-then planning

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ABSTRACT

The self-regulation strategy of forming implementation intentions has now been studied for almost 30 years. We trace the development of this research and explicate the questions that have been addressed. We then present current research that investigates the consequences of implementation intentions for flexible goal striving, behaviour in situations for which one had not planned, and neuropsychological processes underlying the action control by implementation intentions. Next, we turn to novel applications focusing on how implementation intentions affect physical endurance and promote strategic information processing. Our review concludes with an outlook on future research on implementation intentions that covers emerging individual difference perspectives, innovative approaches to characterize underlying cognitive processes, and the prospects of integrating insights from related fields of research. As such, our review is an empathic call for addressing the many intriguing conceptual and empirical questions that still revolve around implementation intentions.

ARTICLE HISTORY Received 14 September 2019; Accepted 7 August 2020

KEYWORDS Motivation; goals; implementation intentions; behavior change; planning

One score and seven years ago, Peter Gollwitzer (1993) published the article "Goal achievement: The role of intentions" in this journal. He started out with a discussion of the intensive controversy between Kurt Lewin and Narziss Ach on the features, functions, and processes regarding people's intentions. Lewin adhered to the perspective of motivation psychology suggesting that intentions are best understood as quasi-needs, whereas Ach clearly adhered to the view of cognitive psychology suggesting that intentions are nothing more than associative links between prospective situations and the planned respective responses. Over the course of the controversy, the conceptual arguments were refined on both sides and empirical evidence supporting each view was accumulated – and the controversy remained unresolved.

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Meanwhile, motivation scientists were focusing on the determinants and strength of intentions. The theory of planned behaviour, for instance, illuminated how attitudes, norms, and control beliefs act as precursors of behavioural intentions (Ajzen, 1991). It was assumed that once people had sufficiently committed to pursuing their goals, behaviour should follow suit. And indeed, strong correlations between intentions and subsequent behaviour (r = .53; Sheeran, 2002) highlight the importance of strong goal commitment for successful goal attainment. However, goal attainment often requires more than merely setting a goal – an assertion corroborated by research suggesting that people often fail to act upon their goals. For instance, only about half of those who want to engage in physical activity perform the intended behaviour (meta-analysis by Rhodes & de Bruijn, 2013), implying various negative effects on the health and well-being of the remaining half. And people also fail to act upon their goals in many other domains of personal and societal importance, for instance, when they fail to search for a new job after becoming unemployed (Van Hooft et al., 2005) or to comply with their environmental goals (Kollmuss & Agyeman, 2010). This intention–behaviour gap (Sheeran & Webb, 2016) calls for an explanation of when people succeed or fail with translating their intentions into behaviour.

When revisiting the Ach–Lewin controversy in the 1993 paper, Gollwitzer offered a pragmatic solution. He argued that there might be two distinct types of intentions. First, there are goal intentions which specify goals related to certain outcomes or actions – for instance, *"I want to lose 10 pounds"* or *"I want to eat more fruit"*. And second, there are implementation intentions which specify when, where, and how one wants to perform goal-directed responses such as instrumental thoughts, feelings, or actions that help to realize the formed goal intention. Importantly, they need to be linked to critical situational cues that specify either an opportunity to be seized or an obstacle that needs to be overcome. Research has shown that such "linking" works best when done in an if-then format – for instance, *"and if I am on the search for a snack, then I will eat an apple first"* (see Table 1). This distinction between goal intentions and implementation intentions has instigated enormous research efforts leading to hundreds of empirical studies from different labs across various countries showing the effects of implementation intentions on people's goal attainment as well as investigating the underlying processes working towards closing the gap (Gollwitzer, 2014; Gollwitzer & Sheeran, 2006).

Whereas the 1993 article focused on whether and how implementation intentions help people get started with goal striving, soon questions were raised of whether and how implementation intentions could also be used to enhance the shielding of goal striving from disruptions or to facilitate calling a halt when goal striving became unproductive. Moreover, it was asked whether basing one's goal striving on implementation intentions makes

Table 1. Format of Goal and Implementation Intentions and Possible Components of If- and Then-Parts.

Goal intentions: *I want to achieve outcome X/perform behaviour Y!*	
Implementation intentions: *If I encounter situation Z, then I will perform behaviour Y!*	
If-Part	• opportunity (*good point in time, suitable event*) • obstacle (*critical resistance from within or outside the person*)
Then-Part	• affective response (*adopt a feeling, down-regulate a feeling, up-regulate a feeling, switch from one feeling to another, keep calm)* • behavioural response (*initiate a response, inhibit a response, intensify a response, switch from one response to another)* • cognitive response (*think of something (content), adopt a certain mode of thought (thinking style)*)

goal striving less taxing, and whether this is true for all kinds of goals such as consumer, academic, prosocial, health, and environmental goals (summaries by Gollwitzer, 1999; Gollwitzer & Sheeran, 2006).

Research also turned to the question of whether and how one can use implementation intentions for down-regulating unwanted thoughts, feelings, and habits, and whether there are moderators of implementation intention effects pertaining to the features of the goal-striving individual, of the implementation intention that is formed, of the respective goal intention, and of the situational context during the forming of the implementation intentions as well as the acting on it. In addition, research on implementation intentions has kept targeting the question of how implementation intentions achieve their powerful effects on goal attainment. This research used sophisticated cognitive task paradigms and discovered a process referred to as strategic automaticity, meaning that the deliberate act of forming implementation intentions prepares automatic processes that help the detection of the specified critical situation and the initiation of the linked specified response once this situation is encountered (summary by Gollwitzer, 2014).

In the present paper, we want to show that while extensive research on implementation intentions has been conducted and published by now, there is still a host of unanswered questions that await a critical analysis at the conceptual and empirical level. Before presenting these pressing research questions and the ongoing respective research, we briefly review research on the processes behind implementation intention effects that the reader will need to be aware of in order to critically assess the importance and quality of the ongoing research. We will then turn to discussing research on (1) whether implementation intentions manage to strike the balance between flexible and tenacious goal striving, (2) how they affect behaviour in non-planned situations, and (3) how their processes and effects are reflected in the brain. We will then turn to two novel applications of implementation intentions, focusing on whether they (1) affect physical performance by altering perceptions of demand and (2) alter decision making by enabling strategic switches between different modes of information processing. We will

conclude with an outlook delineating future directions for implementation intention research.

How do implementation intentions work? Putting behaviour on autopilot

Two cognitive processes have been proposed to mediate implementation intention effects on behaviour (e.g., Parks-Stamm et al., 2007; Webb & Sheeran, 2007). First, the mental representation of the critical situation specified in the if-part is assumed to become activated and thus highly accessible (Aarts et al., 1999). This heightened cognitive accessibility has important downstream effects on memory, attention, and perception. People are more likely to recall the information specified in implementation intentions, and they involuntarily attend to it even when doing so hampers their task performance (Achtziger et al., 2012). Further, implementation intentions have been found to facilitate even the earliest perceptual processing of relevant information (Janczyk et al., 2015). Taken together, implementation intentions allow people to readily detect goal-relevant opportunities and obstacles as they emerge in their environment.

Second, implementation intentions are assumed to create a strong associative link between the critical situation and the goal-directed response, allowing people to automatically initiate the planned response once they encounter the specified situation. This assertion has been corroborated by showing that action control by implementation intentions is characterized by the various features of automaticity (see Bargh, 1994): immediacy (e.g., Gollwitzer & Brandstätter, 1997), efficiency (e.g., Brandstätter et al., 2001), independence from conscious intent (e.g., Bayer et al., 2009), and reduced controllability (e.g., Wieber & Sassenberg, 2006). Moreover, the associative links created by implementation intentions are stable over time and thus allow postponing planned behaviour to future events (Papies et al., 2009).

Current research on the consequences of forming implementation intentions

Tenacious and flexible goal striving

Goal striving involves several challenges that must be mastered in order to attain a goal (Gollwitzer & Oettingen, 2016; Sheeran & Webb, 2016). One of these challenges is to strike a balance between tenacity and flexibility (Brandtstädter & Rothermund, 2002; Gollwitzer et al., 2008). Sometimes it requires tenacity to stay on track rather than offhandedly abandoning one's goal at the first sign of trouble. Sometimes it requires flexibility such as when performing the goal-directed behaviours becomes excessively costly and

continued efforts seem futile. How implementation intentions affect this balance has been addressed from the perspective of motivational intensity theory (Brehm & Self, 1989). Concerned with the processes that determine effort mobilization, this theory's basic assumption is that more effort is invested as the goal becomes more challenging until the expenditure of effort seems either unjustified or impossible. As such, it suggests an interesting perspective on how forming implementation intentions might strike a balance between tenacious and flexible goal striving. On the one hand, they automate goal-directed behaviour and should therefore reduce the perceived demand of attaining a goal, rendering goal striving tenacious. On the other hand, even after having formed them, people should back off from investing effort when their commitment to the goal is reduced, which might be a consequence of seeing the expenditure of effort as unjustified or impossible.

Evidence for tenacity

The assumption that implementation intentions permit tenacious goal striving by reducing the perceived demand of performing goal-directed behaviours has been investigated in two psychophysiological experiments by Freydefont et al. (2016). In Experiment 1, 47 undergraduate students performed an easy digit-classification task in which they had to discriminate between single and multiple-digit numbers. In Experiment 2, 72 undergraduates had to mouse-track a moving circle on the computer screen and to concurrently respond with mouse clicks to letters appearing in the circle. By varying the size of the circle, the authors created a difficult and a very difficult version of this task. Before participants started working on these tasks, they received control instructions or were asked to form goal or implementation intentions in both experiments. For instance, in Experiment 2 these instructions read *"I will pay particular attention to the numbers!"* (control), *"I will click the left mouse button very quickly when a number appears!"* (goal), and *"If a number appears, then I will click the left mouse button very quickly!"* (implementation intention). Effort-related cardiac activity was operationalized by the duration of the cardiac pre-ejection period (PEP) during the tasks relative to the pre-task baseline, as a shorter PEP provides a reliable physiological measure of effort mobilization (Kelsey, 2012).

In the easy task used in Experiment 1, goal and implementation intention participants alike performed better than control participants while investing less effort, as indicated by a weaker decrease in PEP (see Table 2). In the difficult task of Experiment 2, implementation intention participants performed at the same level as control and goal intention participants but mobilized less effort. In comparison, however, they invested more effort in the very difficult task, while participants in the other conditions invested less. These results are in line with the assumption that implementation intentions

Table 2. Means and Standard Errors of Cardiac Pre-Ejection Period (PEP) Reactivity (in Milliseconds).

	Experiment 1			Experiment 2					
	Easy task			Difficult task			Very difficult task		
Condition	*N*	*M*	*SE*	*N*	*M*	*SE*	*N*	*M*	*SE*
Control	16	−7.03	2.21	15	−2.42	1.29	8	−1.25	1.06
Goal intention	16	1.47	1.43	12	−2.78	1.82	15	4.28	2.01
Implementation intention	15	−0.84	1.37	10	0.37	2.19	12	−2.18	1.56

Note. The table is based on Freydefont et al. (2016). Reactivity scores were determined by subtracting baseline from task activity, such that smaller (i.e., more negative or less positive) values represent increased effort mobilization.

reduce perceived demand, lowering the effort associated with task performance and thus facilitating more tenacious goal-directed behaviour.

Evidence for flexibility

A second prediction derived from motivational intensity theory is that people should cease to invest effort into their goal striving once it seems unjustified or impossible. Importantly, because goal striving is initially eased by forming implementation intentions, this point should be reached at a later stage. However, people should still disengage once they perceive the mobilization of additional effort as unjustified. To test this prediction, Legrand et al. (2017) conducted three experiments in which a total of 240 students worked on a computerized card-colour matching task. They saw sets of two target and two non-target cards on the screen and were instructed to indicate the position of one of the two target cards as quickly as possible. They furnished this instruction either with a goal intention (*"I intend to choose a correct card as quickly as possible!"*) or an implementation intention (*"If I see a card with the same colour as the card at the top of the screen, then I will press the corresponding key as quickly as possible!"*). Importantly, one target card appeared earlier than all the other cards. Choosing this critical card therefore was the most instrumental behaviour in keeping with the goal to work as quickly as possible. On the downside, however, participants subsequently experienced that choosing the critical card had slightly aversive (hearing white noise and having to press the spacebar repeatedly in Experiments 1 and 2, respectively) or very aversive consequences (monetary loss in Experiment 3). Participants therefore faced a trade-off between choosing the critical card to attain their goal and avoiding the aversive consequences linked to choosing it. This experimental setup allows a straightforward investigation of whether people back off from their implementation intentions once investing the effort seems unjustified. The frequency of choosing the critical card as goal-directed behaviour served as the dependent variable (Table 3).

This is in line with the finding that implementation intentions render difficult goal striving tenacious (Freydefont et al., 2016). Critically and

Table 3. Percentages of Critical Card Choices and Odds Ratios.

	Experiment 1			Experiment 2			Experiment 3		
	% Choice			% Choice			% Choice		
	1st	4th	OR	1st	4th	OR	1st	4th	OR
Goal intention	73.6	60.2	0.32***	73.4	63.4	0.44***	59.9	39.0	0.16*
Implementation intention	72.4	70.0	0.70	73.8	76.6	1.49*	72.1	30.5	0.02***

Note. The table is based on Legrand et al. (2017). % choice refers to the percentage of critical cards chosen in the 1st and the 4th quarter of the experiment. OR refers to the odds ratio. *p <.05. ***p <.001.

complementing this finding, however, when in Experiment 3 participants faced very aversive consequences of choosing the critical card, they became less likely to perform the goal-directed behaviour in both the goal and the implementation intention condition. This suggests that goal striving with implementation intentions is tenacious but still allows people to flexibly disengage from a goal that does not justify the costs associated with its attainment.

Failure to attain a goal

The research reported so far illustrates that motivational intensity theory provides a framework for explaining and predicting how implementation intentions strike the balance between flexibility and tenacity. Yet, this theory allows to derive additional interesting predictions; for instance, on the interplay between perceived demand and goal striving by implementation intentions in the case of failure to attain a goal. As argued above, goal striving with implementation intentions should be perceived as less demanding and therefore easier than goal striving with goal intentions. It is conceivable that people attribute failure to attain the goal more strongly to themselves than to other factors like the (easier) task at hand and such failure might accordingly produce more psychological discomfort among individuals who furnished their goal with implementation intentions. This reasoning is in line with research showing that people with a disposition to engage in if-then planning tend to feel uncomfortable when failing to make progress towards their goals (Bieleke & Keller, 2020). We hasten to add, however, that this serves as an illustration for how motivational intensity theory could fruitfully guide future research on implementation intentions beyond the issue of flexibility and tenacity rather than as a definite answer on how goals and plans affect emotional responses to failure.

Spill over effects to non-planned situations

The studies reported in the last section reveal how implementation intentions can strike the balance between tenacity and flexibility. However, they all focus on whether people perform their goal-directed behaviour in the situation specified in their implementation intentions – the predominant focus in

implementation intention research. But this is a quite narrow perspective given that people might encounter non-planned situations which might vary in similarity to the critical situation and might or might not require the planned goal-directed behaviour. How does forming implementation intentions affect behaviour in such non-planned situations?

Generalization effects

One line of research tested the hypothesis that people perform the planned behaviour not only when encountering the planned critical situation but also when encountering sufficiently similar non-planned situations. In one study by Epton and Armitage (2017), 133 office workers in the UK filled out a questionnaire measuring their engagement in physical activity. Afterwards, participants received a "volitional help sheet" specifying potential obstacles for engaging in physical activity along with goal-directed behaviours to overcome them. A multi-obstacle sheet specified ten specific obstacles (e.g., *"If I'm tempted not to be physically active because my gym is closed"*) and ten behaviours (e.g., *"then I will tell myself that I will feel more confident in myself if I were more physically active"*). In contrast, a single-obstacle sheet specified the same ten behaviours but only one general obstacle (*"If I'm tempted not to be physically active"*). Control participants received the multi-obstacle sheet and merely ticked those obstacles and behaviours that were most relevant to them. Implementation intention participants received either the multi-obstacle or the single-obstacle sheet and were instructed to draw lines between all relevant obstacles and behaviours to establish if-then plans. After two months, participants again completed the same physical activity questionnaire. The authors found that physical activity had increased among implementation intention participants but decreased among control participants. Importantly, it did not matter whether implementation intention participants specified only one general or several specific obstacles, supporting the idea that implementation intention effects might generalize to similar situations, still triggering the planned response.

Even more convincing support for this conclusion comes from a study on speeding behaviour conducted with 139 active drivers in the UK (Brewster et al., 2016). The participants performed a driving simulation in the lab, in which driving in urban traffic was simulated under realistic conditions (e.g., 135° driver field-of-view). During the simulation, they encountered three critical situations that are known to increase the likelihood of speeding (e.g., being stuck behind a slow-moving vehicle). Before the task, participants formed implementation intentions using volitional help sheets that specified three situations and 20 goal-directed behaviours. Three conditions were established in which the specified situations were either identical to the critical situations (e.g., *"after I have been stuck behind a slow moving vehicle"*), contextually similar (e.g., *"after I have been stuck in stationary traffic"*),

or contextually dissimilar (e.g., *"when traffic lights turn against me"*). The specified goal-directed behaviours were kept constant across conditions (e.g., *"drive in a lower gear to help me drive slower"*). In an additional control condition, participants read relevant educational messages rather than forming implementation intentions. As the dependent variable, the authors compared the frequency of speeding in the critical situations between the four conditions. They found that participants with implementation intentions showed less speeding behaviour than participants in the control condition when the specified situations were identical or similar to the critical situations. This generalization of implementation intention effects might contribute to their robustness and long-term effectiveness because it facilitates goal attainment when situational cues are difficult to predict (novel) or subject to change (volatile). Interestingly, implementation intentions formed for dissimilar situations were not effective in reducing speeding behaviour, although goal attainment would have benefitted from the execution of the planned behaviour in these situations as well.

Missing opportunities to act

This latter observation fits to a second line of research on implementation intention effects in non-planned situations, which focuses on situations not resembling the planned one but still requiring the planned response. This research commonly starts from the assumption that forming implementation intentions prioritizes a single situation–behaviour link, thereby putting alternative links at a disadvantage. In one test of this hypothesis, Parks-Stamm et al. (2007, Study 1) invited 56 undergraduates to a lab study in which they listened to a recorded story. Their task was to identify as many five-letter words as possible and to respond to these words by typing their initial letters. In the goal condition, participants were informed that two target words in the story are "mouse" and "Laura" and asked to familiarize themselves with the responses to them (i.e., pressing "M" and "L", respectively). In addition to that, implementation intention participants planned out their response to the target words (e.g., *"if I hear the word 'mouse,' then I will immediately press M"*). The authors then measured how many occurrences of the two target words and of alternative five-letter words participants in the goal and the implementation intention condition identified correctly. They observed that implementation intention participants were more likely to identify the target words than goal intention participants (M = 21.4, SD = 2.1 versus M = 19.7, SD = 2.6) but less likely to identify alternative five-letter words (M = 10.6, SD = 4.5 versus M = 12.4, SD = 2.7). This underscores the effectiveness of implementation intentions for goal attainment in planned situations, while suggesting that they hamper the performance of goal-directed behaviours in situations that are not specified in the plan.

This can disadvantage a person's goal attainment, in particular when seizing non-planned opportunities is the only way to attain a goal. Creating such a situation in a lab study, Masicampo and Baumeister (2012) asked 102 undergraduates to visit several websites and to answer a set of questions for each of them. Importantly, participants were given the overarching goal of looking up actor Bill Murray's birth year using any website they wished. In the goal condition, participants familiarized themselves with the goal by typing "Bill Murray's birth year" but they did not commit to a specific website. In the implementation intention condition, in contrast, participants planned to use the Internet Movie Database (imdb.com) for looking up the fact (i.e., "*When I get to imdb.com, I will look up Bill Murray's birth year*"). The task was then set up so that some participants never encountered imdb.com and could attain the goal only by using wikipedia.org, whereas others encountered both websites. The dependent variable was the percentage of participants in each condition who succeeded at retrieving Bill Murray's birth year.

When participants encountered imdb.com, those in the implementation intention condition were more successful in looking up Bill Murray's birth year than participants in the control condition. However, when imdb.com was not encountered and only wikipedia.org could be used, participants with a goal intention outperformed those with an implementation intention. This finding indicates that implementation intentions indeed impair goal attainment if successful goal attainment requires performance of the goal-directed behaviour in a non-planned situation.

Performing alternative behaviours

The research reviewed so far demonstrates that implementation intentions affect behaviour not only in planned but also in non-planned situations. However, these studies focus solely on cases in which the planned behaviour should be performed in (similar or different) non-planned situations. But what happens when goal attainment requires a behaviour that differs from the planned one? For instance, people might erroneously perform the goal-directed behaviour in similar situations that in fact require different behaviours (e.g., taking a planned route to work on the weekend). Also, people might not seize alternative means to goal attainment in situations that differ from the planned one (e.g., taking an elevator instead of the stairs to go to the gym).

Bieleke et al. (2018) addressed this issue in a series of three experiments in which a total of 284 undergraduate students classified geometric figures on the computer. In their third experiment, the authors fully disentangled the effects of forming implementation intentions in planned and non-planned situations that require the planned behaviour or an alternative one. They emphasized one critical geometric figure (e.g., a plain square) in the

instructions and participants either formed a goal intention (*"I intend to categorize [picture of the critical figure] as fast as possible!"*) or an implementation intention (*"If I see [picture of the critical figure], then I'll press [the corresponding key] as quickly as possible!"*) to categorize it quickly by pressing a corresponding key. The classification task comprised several other figures of either similar or dissimilar appearance. Moreover, these other figures required either the same response as the critical figure or a different one. Response time and the percentage of correct classifications were used as indicators for how implementation intentions affected behaviour in these situations in comparison to goal intentions.

The results of the experiment are summarized in Table 4. First, implementation intentions sped up responses to the critical figure compared to goal intentions without loss in accuracy, and this effect carried over to figures of similar appearance requiring the same response. This is in line with the commonly observed facilitative effects of implementation intentions on goal-directed behaviour and provides additional evidence for their generalization to non-planned situations. Second, implementation intention participants committed more errors when figures required the same response as the critical figure but were of dissimilar appearance. This aligns well with research showing that implementation intentions increase the probability of missing alternative opportunities to act towards a goal. Third, implementation intention participants also committed more errors when encountering figures that were of similar appearance as the critical figure but required a different response. This observation goes beyond the research described above as it suggests that implementation intentions make it difficult to withhold the planned response in situations similar to the one specified in the plan, analogous to habit capture errors.

Taken together, research on implementation intention effects in non-planned situations reveals both facilitative and disadvantageous effects on goal attainment. Making if-then plans seems to help in sufficiently similar

Table 4. Response Times in Milliseconds (Means and Standard Deviations) and Accuracy (Percentage of Correct Classifications).

	Goal intention			Implementation intention		
	Response time		Accuracy	Response time		Accuracy
Figure	*M*	*SD*	%	*M*	*SD*	%
Critical	721.2	189.4	97.3	624.1	139.1	96.2
Similar appearance						
Same response	727.9	166.7	95.2	656.3	158.7	95.5
Different response	826.2	159.2	94.3	796.4	162.7	90.5
Dissimilar appearance						
Same response	844.8	145.0	90.5	816.2	166.2	83.7
Different response	815.6	144.8	93.2	772.1	151.5	92.3

Note. This table is based on Bieleke et al. (2018, Experiment 3).

situations that require the planned response, which is a desirable feature when specific situations are difficult to foresee or environmental conditions might change. However, forming implementation intentions might backfire when successful goal attainment requires different responding in a situation resembling the planned situation or when the execution of the planned goal-directed response is required in non-planned situations.

One might argue that there are easy solutions for dealing with such unintended effects, such as forming multiple implementation intentions. Unfortunately, planning for different situations (e.g., cues for unhealthy snacking; Verhoeven et al., 2013) and/or planning different behaviours (e.g., a "Plan B", Vinkers et al., 2015) might even reduce the effectiveness of implementation intentions. A more promising strategy therefore is to take advantage of what at first glance appears to be undesired effects of implementation intentions. For instance, people could plan to indulge in opportune situations (e.g., "If I am on the exercise bike in the gym, then I will watch my favourite Netflix series!") to exploit the observation that such a planned behaviour becomes less likely to be performed in non-planned situations that are less suitable for indulging (e.g., doing the chores at home). Another solution might be to form implementation intentions that are sufficiently general and thus cover a broad range of relevant situations or behaviours – such as planning to adopt a reflective mode of thinking (discussed below).

Cerebral correlates of implementation intention effects

The consequences of forming implementation intentions reviewed so far are consistent with the notion of strategic automaticity, which describes implementation intentions as a goal-dependent and automatic form of action control. This notion is also corroborated by studies investigating the temporal distribution and the spatial location of implementation intention effects in the brain (for an overview, see Wieber et al., 2015b).

Temporal distribution

Regarding the temporal distribution of implementation intention effects, studies have mostly relied on electroencephalography (EEG). These studies have shown that implementation intentions modulate indicators of the early processing of presented information, such as the P100, P300, and N170 event-related potential components. Paul et al. (2007), for example, asked 13 children diagnosed with attention deficit hyperactivity disorder (ADHD) and 16 age-matched children without such a diagnosis to perform a go/no-go task. In go trials, the children categorized drawings of animals and vehicles by pressing corresponding buttons. In no-go trials, a hand symbol signalled to withhold any response and thus required effective response inhibition,

observable in the EEG as a stronger amplitude of the P300 component compared to go trials (Picton, 1992). Healthy controls withheld responses in no-go trials slightly more often (95%) than children with ADHD (87%), accompanied by a stronger go/no-go amplitude difference during the first half of the P300 (i.e., 160 to 312 ms after stimulus onset). Forming implementation intentions for the no-go trials (*"If I see a hand, then I will not press any button"*) reduced this small difference even further (95 versus 90%). More importantly, the amplitude difference between healthy children and children with ADHD in the second half of the P300 (i.e., 312 to 452 ms after stimulus onset) was remarkably reduced in the implementation intention condition, suggesting an improved response inhibition among children with ADHD. Given the small sample size in this study, it is notable that subsequent studies have replicated these findings among healthy adults (e.g., De Pretto et al., 2017) and other stages of information processing. For instance, implementation intentions reduced differences between threatening and non-threatening stimuli among people with fear of spiders in the P100 amplitude (Schweiger Gallo et al., 2009) and stereotype processing manifested in the N170 amplitude (Hügelschäfer et al., 2016). In sum, EEG studies indicate that implementation intentions modulate early processing of information.

Spatial location

Other research has focused on the spatial location of implementation intention effects in the brain, mostly using functional magnetic resonance imaging (fMRI). The main hypothesis here is that implementation intention effects should involve brain areas associated with stimulus-oriented, bottom-up processing rather than with deliberate, top-down processing. For example, Gilbert et al. (2009) assumed differential activation in medial versus lateral areas of the rostral prefrontal cortex (BA 10) between action control by implementation intentions versus goal intentions, because these areas are associated with bottom-up stimulus triggered processing versus top-down goal-guided processing of information, respectively. To test this idea, the authors asked 16 healthy undergraduates to perform two tasks in the fMRI scanner. In one task, an uppercase and a lowercase letter appeared side by side (e.g., "e" and "X") and participants pressed left and right buttons to indicate the position of the uppercase letter. In rare target trials, however, the same letter of the alphabet appeared on both sides (e.g., "f" and "F") and participants were required to press a middle button. In the implementation intention condition, participants planned this response (*"If the same letter is on both sides, then I will press the middle button!"*). Participants in the goal intention condition instead made a control plan describing the outcome of the response (*"If the same letter is on both sides, then I can score five points!"*). The assignment of participants to conditions was reversed for the second

task, in which a pair of dots were presented on one side of the screen and a single dot on the other side, and participants indicated the position of the pair of dots. In target trials, all three dots formed a straight line and required a middle button press. The authors focused on whether and how fast participants pressed the correct button in target trials and on brain activity.

On a behavioural level, participants pressed the correct button in target trials more often when they had formed implementation intentions (76%) rather than goal intentions (65%), with response times being similar. The authors also found the predicted differences in BA 10 activity: Target responses were associated with medial BA 10 activity in the implementation intention condition but with lateral BA 10 activity in the goal intention condition. This corroborates the notion that implementation intentions activate regions in the brain that are involved in bottom-up processing, whereas goal intentions recruit regions associated with top-down processing.

Subsequent studies have replicated this finding in the domains of emotion regulation (Hallam et al., 2015) and physical activity (Wolff et al., 2018). Wolff et al. (2018) recruited 60 female students to perform a muscular endurance task that involved holding two intertwined rings for as long as possible while avoiding contacts between the rings. To deal with exertion, participants in the goal condition formulated a goal (*"The task is to persist for as long as possible while avoiding contacts between the rings!"*) which participants in the implementation intention condition complemented with an if-then plan (*"If the task becomes too strenuous for me, then I will ignore the strain and tell myself: 'Keep going!"*). Cerebral activity in the lateral prefrontal cortex (LPFC) – a brain region associated with effortful top-down control – was measured with functional near-infrared spectroscopy (fNIRS). Compared to control participants, lower LPFC activity was observed among implementation intention participants throughout the task, suggesting a reduction of effortful regulation (see Figure 1). This was not, however, accompanied by better endurance performance. While in line with earlier research showing that implementation intention effects rely less on brain regions associated with effortful top-down control, these results suggest that automating behaviour may not always improve performance.

In sum, research on the temporal distribution and spatial location of implementation intention effects supports the notion of strategic automaticity. It demonstrates that implementation intentions affect even the earliest stages of processing information, putting them *at par* with automatic processes that are otherwise difficult to control (e.g., stereotyping). Moreover, they recruit brain areas associated with bottom-up, automatic action control, whereas goal intentions rely on brain areas associated with top-down, deliberate action control.

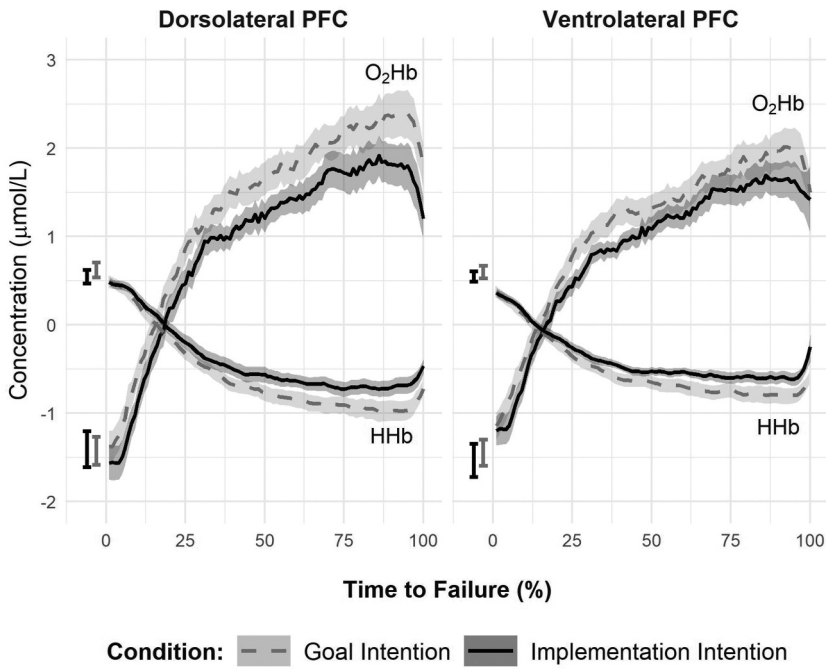

Figure 1. Activity in the Prefrontal Cortex (PFC) During a Muscular Endurance Task Among Participants with Goal versus Implementation Intentions.
Note. The upward and downward trending lines represent O_2Hb and HHb, respectively, as a function of time to failure in the task and condition. The shaded regions represent standard errors (SE) and error bars represent baseline averages ± 1 SE. Modified reproduction of Figure 3 from Wolff et al. (2018) based on the terms of the Creative Commons CC BY license.

Novel applications of implementation intentions

Regulating effort during athletic endurance performance

As we have argued above, implementation intentions reduce the perceived demand of performing a task. This is desirable in situations that require to endure effort over extended periods of time, such as endurance sports. However, empirical tests of implementation intention effects on effort and performance in physical endurance tasks are scarce (Wolff et al., 2019), although they have been suggested as a helpful self-regulation strategy (e.g., Brick et al., 2016).

In an exception to this, Thürmer et al. (2017) had 156 university students form triads who reached out their dominant hands to hold a medicine ball collectively for as long as possible. There were two rounds of this task and in

between them triads were assigned to one of four conditions. In two implementation intention conditions, they planned how to deal with muscle pain either individually or as a group ("*And if my [our] muscles hurt, then I [we] will ignore the pain and tell myself [ourselves]: I [We] can do it!*"), while participants in two goal intention conditions received corresponding control strategies ("*I [We] will ignore my [our] muscle pain and tell myself [ourselves]: I [We] can do it!*"). If implementation intention participants indeed downregulate their pain automatically, they should perceive the task as less difficult and thus hold the medicine ball for longer than goal intention participants. In line with this hypothesis, the authors observed that participants in the two implementation intention conditions held the ball longer in Round 2 compared to Round 1 than participants in the two corresponding control conditions (Table 5).

However, implementation intentions do not always enhance endurance performance. We have already described the study by Wolff et al. (2018) using fNIRS in which implementation intentions affected cerebral activity but without improving performance in a muscular endurance task. In a similar study with 62 female students, Bieleke and Wolff (2017) continuously measured participants' self-reported exertion on a scale from 0 (*nothing at all*) to 10/11 (*maximal/more than max*) while using identical task and plan instructions. Whereas endurance performance again did not differ between implementation intention and control participants, the authors observed that implementation intention participants became more rapidly exhausted during the task and reached a higher total level of exertion than control participants ($M = 9.4$, $SD = 1.7$ vs. $M = 8.2$, $SD = 2.5$). The lack of an implementation intention effect on endurance performance might thus be interpreted in terms of ironic processing theory (Wegner, 1994): Planning to ignore sensations of strain might backfire by promoting intrusions of the suppressed thoughts or sensations, amplifying the undesired experience of strain (Janelle, 1999).

It should be noted that these studies on endurance performance are limited to student samples with heterogeneous athletic experience and artificial athletic tasks. In more naturalistic settings with experienced athletes the effects of implementation intention on performance might be different. For example, Achtziger et al. (2008, Experiment 2) recruited 107 competitive

Table 5. Means and Standard Deviations of Persistence (Seconds).

	Goal intention				Implementation intention			
	Individual goal		Group goal		Individual plan		Group plan	
Round	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	190.86	54.14	193.58	77.49	212.60	81.33	139.82	44.54
2	142.07	44.20	176.00	73.39	181.80	61.09	159.64	41.58
1–2	−48.79	28.75	−17.58	39.53	−30.80	62.03	19.82	34.76

Note. This table is based on Thürmer et al. (2017, Experiment 1).

tennis players who regularly participated in tournaments of different German leagues. One day before a match, players in a goal and an implementation intention condition set a goal ("*I will play each ball with utmost concentration and effort in order to win the match!*"), while those in a control condition set no goal. Participants in the implementation intention condition added four individual if-then plans to the goal, drawing upon prepared lists of potential obstacles and goal-directed behaviours. As a dependent variable, the authors asked the players as well as their coaches and teammates to rate performance and fitness during the match compared to previous matches. This revealed that implementation intention participants performed better and were fitter (M = 0.23, SD = 0.10) than participants in the control (M = −0.15, SD = 0.12) and the goal intention condition (M = −0.10, SD = 0.10).

It is also important to note that the endurance studies conducted so far focused on ignoring or suppressing negative sensations. While implementation intentions can downregulate undesired sensations and behaviours (Schweiger Gallo et al., 2009), they have been observed to hamper goal attainment in some cases as well (Adriaanse, van Oosten et al., 2011). It thus seems promising to augment the existing research on implementation intentions effects on effort regulation during endurance performance by testing potential moderators (e.g., beliefs about effort and pain as limiting factors for performance; Hirsch et al., 2020).

Strategizing the integration of information

The majority of research on implementation intentions has focused on cases in which implementing goal-directed behaviours is challenging (e.g., sticking to a training regimen) but making the underlying decision is simple (e.g., deciding to lose weight). However, making the decision itself can be difficult when people struggle with integrating a host of available information. In these situations, they might benefit from planning to focus on how information is processed. It might be difficult to foresee exactly which way of dealing with information might be best suited in a future situation. For instance, situations might require putting similar weight on evaluating desirable and undesirable information, to ignore information that may distract from making an optimal decision, to actively search for potentially relevant information, or to shield the processing of information from potential biases. This variety of challenges can make it difficult to specify a single best response in an implementation intention; instead, people might benefit from engaging in a more general mode of processing (e.g., intuitive versus reflective) or evaluating information from a certain perspective (e.g., a neutral observer). Whether planning can help people switch strategically to certain modes of

processing and perspectives is a question that has attracted much attention in recent implementation intention research.

Thinking carefully about investments

Wieber et al. (2015a) focused on the phenomenon of escalation of commitment, which occurs when people feel responsible for previous decisions and threatened by negative feedback. Accordingly, the authors tested whether planning to adopt the neutral perspective of someone not responsible for earlier decisions might help people deal with negative feedback. In their Experiment 1, 117 students formed triads simulating city councils involved in a kindergarten construction project. They set the goal to make optimal decisions and supplemented it with a control strategy ("*We want to judge the project as neutral observers who are not responsible for earlier investment decisions!*") or formed an implementation intention ("*If we are about to make an investment decision, then we will judge the project as neutral observers who are not responsible for earlier decisions!*"). The project comprised three consecutive phases in which triads received feedback on the status of the project that went from positive in Phase 1 to mixed in Phase 2 to negative in Phase 3. In each phase, the triads could adjust the budget allocated to the project. The results showed that goal participants failed to adjust the budget to the feedback, suggesting that they fell prey to escalating commitment. Implementation intention participants, in contrast, reduced their investments over the course of the project. The authors replicated these results in an independent second experiment (Figure 2). Importantly, the implementation intentions used in these experiments prescribed taking a certain perspective rather than committing participants to a specific behaviour (e.g., abandoning the project) or thought (e.g., reconsidering previous decisions). Accordingly, the findings suggest that people can switch to separate ways of thinking, and that doing so can have beneficial effects.

Corroborating evidence for this conclusion comes from a study by Doerflinger et al. (2017, Study 3) in which 102 students played a computerized game of poker. In this game, there were five common cards face down and each player had an additional two own cards face up. The player whose own cards together with the common cards made the better hand won the game. To make this comparison, however, the players had to invest money into revealing the common cards one by one. Each card thus added information about the chance of winning, which players could use to decide whether to continue their investments or opt out. The authors hypothesized that participants who plan to think thoroughly ("*If the situation looks unfavourable, then I will deliberate thoroughly!*") are less likely to continue their investment as the probability of losing increases, compared to participants who plan to make intuitive decisions ("*If the situation looks unfavourable, then I will decide quickly and spontaneously!*") or set a mere

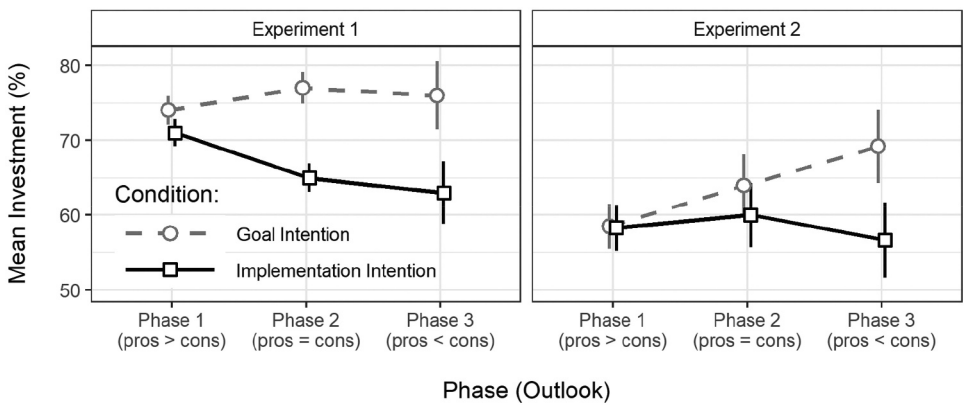

Figure 2. Investments in the Kindergarten Project in the Goal and the Implementation Intention Condition Across Three Phases of Deteriorating Feedback. *Note*. Error bars represent standard errors of the mean. Figure adapted from Figures 1 & 2 in Wieber et al. (2015a). Copyright (2015) pertains to the authors. Adapted with permission.

goal to perform well ("*I want to make as much money in this experiment as possible!*"). Attesting to a more intensive deliberation process, decision times were shortest in the intuitive plan condition and longest in the reflective plan condition. And while participants in all conditions became less likely to invest money as the odds against them increased, this effect was most pronounced among reflective planners. Thus, the results extend those obtained by Wieber et al. (2015a), indicating that participants can strategically adopt a reflective mode of information processing that helps them make more sophisticated decisions when facing uncertainty.

Thinking carefully about unfair offers

In another study on using implementation intentions to switch between processing modes, Bieleke et al. (2017) investigated the effects of adopting intuitive versus reflective modes of processing in social interactions. A total of 192 students were either assigned to the role of a proposer or a responder in an "ultimatum game," in which the proposers received 20 points and then made ultimatum offers on how to allocate these points between themselves and a responder (e.g., 11 points for them, 9 points for the responder). The responders then decided whether to accept these offers. Accepted offers were implemented and converted to money. Rejected offers, however, meant that both proposer and responder received nothing. The authors assigned the responders to one of three conditions. They either planned to decide in a reflective ("*If I start acting in a hasty way, then I will tell myself: Use your brain!*") or in an intuitive way ("*If I start pondering at length, then I will tell myself: Listen to your guts!*"), respectively, or they made no such plans. In line with Doerflinger et al. (2017), responders in the reflective condition took more time to decide than those in the intuitive condition, especially when an offer was unfair (i.e., yielding 3 points or less for the responder; Figure 3, left panel). They were also more likely to accept these unfair offers than participants in the intuitive condition (Figure 3, right panel).

Bieleke et al. (2020) turned to the effects of planned intuition and reflection on making the allocation decision itself. For their Experiment 2, they assigned 120 students to one of the three conditions established by Bieleke et al. (2017): a reflective plan, an intuitive plan, or a control condition. Afterwards, their social value orientation (SVO; Murphy & Ackermann, 2014) was assessed to measure their prosociality. In this task, participants decided between several possible allocations that varied in their degree of prosociality. Importantly, however, each piece of information about these allocations was hidden behind boxes on the screen and had to be actively acquired moving the mouse cursor. Recording these acquisitions allowed the researchers to analyse the process leading to a decision: the scope and style of information acquisition. It revealed that participants with a reflective plan made more prosocial decisions

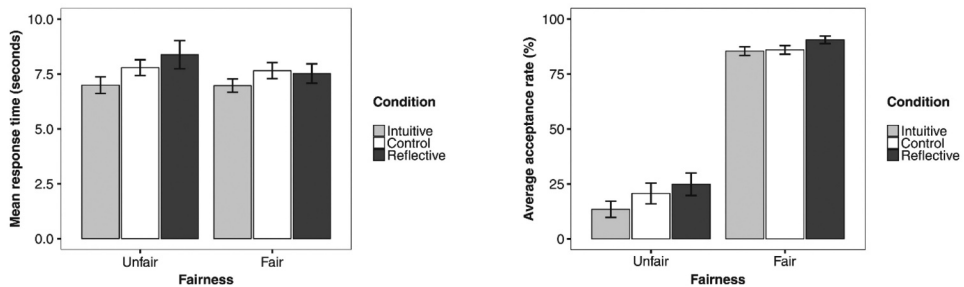

Figure 3. Decision Times and Acceptance Rates as a Function of Condition. *Note*. Error bars represent standard errors of the mean. The figures are taken from Bieleke et al. (2017, Figures 2 & 3). Copyright (2016) by John Wiley & Sons, Ltd. Reprinted with permission.

(i.e., higher SVO score) than those with an intuitive plan. Also, they acquired more information before making their decisions and these acquisitions were more strongly other-oriented (see Table 6).

Taken together, the research presented in this section attests to the notion that people can use implementation intentions to strategically adopt certain modes of information processing or to evaluate information from a certain perspective. These observations add to prior research on implementation intentions that has mainly restricted itself to a focus on planning specific thoughts or actions. It makes planning for the future much more flexible because no specific knowledge about the best response is required other than that a certain processing style (e.g., deliberative thought) or perspective (e.g., neutral observer) might be more beneficial.

Summary and future directions

The central concern in motivation science is to understand what drives people to behave the way they do. A major step in this direction is to investigate the determinants of intentions, such as attitudes, subjective norms, and control beliefs which jointly determine behavioural intentions and their strength (Ajzen, 1991). However, knowing people's intentions does not fully explain their behaviour, as they often fail to act upon even their best intentions (Sheeran & Webb, 2016), providing a starting point for implementation intention theory. Forming implementation intentions is considered a self-regulation strategy that helps people to translate their intentions into behaviour. As such, implementation intentions moderate the relation between intentions and behaviours. A substantive body of literature attests to this assertion and illuminates the cognitive processes behind implementation intention effects. Nevertheless, there are still several important discussions

Table 6. Differences Between the Intuitive and the Reflective Condition in Terms of Prosociality and Information Acquisition.

Model	Dependent variable	β	SE
1	SVO score (prosociality)	10.144*	3.995
Scope of information acquisition			
2	Decision time (log)	0.205*	0.095
3	Total number of acquisitions (log)	0.200*	0.100
4	Number of unique acquisitions (log)	0.182*	0.086
Style of information acquisition			
5	Percent acquisitions of other's payoff	9.961**	3.059
6	Transition index	0.341**	0.113

Note. The table is based on Bieleke et al. (2020, Experiment 2) and gives an overview of six regression models (Models 1–6) in which the dependent variable was regressed on a condition dummy variable (0 = intuitive plan, 1 = reflective plan). The resulting regression coefficients (β) and standard errors (SE) are reported here. Other control variables specified in these models are omitted for clarity. *p <.05. **p <.01.

about the consequences of forming implementation intentions and their potential applications, on which we attempted to shed some light.

Our first focus was on the consequences of forming implementation intentions, specifically on their relation to flexible and tenacious goal striving, their role in generating behavioural spill overs in non-planned situations, and their temporal distribution and spatial location in the brain. We presented research drawing upon motivational intensity theory to demonstrate that people disengage from goals that require seemingly unjustified levels of effort even after having furnished them with implementation intentions. However, they may reach this point considerably later because implementation intentions automate behaviour and thereby render it less effortful, resulting in more tenacious goal striving. Yet, tenacity is less desirable when it turns into overly rigid behaviour. This is a common topic in studies demonstrating that implementation intentions affect behaviour not only in the planned but also in non-planned situations. Consequently, goal attainment is facilitated when the planned behaviour is required in situations similar to the critical one; but it is hampered when such similar situations require non-planned behaviours or when planned behaviours are required in different situations. Overall, these findings are consistent with the notion of strategic automaticity, which is also supported by neuroscientific research. This research reveals that forming implementation intentions results in activation of different brain areas than goal striving with goal intentions, recruiting primarily areas associated with bottom-up, stimulus-controlled action. Moreover, it shows that the effects of implementation intentions are fast enough to modulate even the earliest information processing, thereby outpacing more deliberative forms of action control.

We then turned towards recent applications of implementation intentions, focusing first on their ability to downregulate negative sensations during athletic activities. This research is promising, as it suggests that implementation intentions can indeed affect perceived effort and its cerebral correlates in a meaningful way. However, the direction of these effects is sometimes counterintuitive and beneficial effects on performance were accordingly not always observed. It seems that implementation intentions must be very carefully tailored to the situation at hand to produce the wanted effects. For instance, planning to suppress negative sensations tended to backfire in studies on athletic performance, whereas plans to process information in a specific manner tended to be more effective and facilitated goal attainment in expected ways. This observation blends in well with using implementation intentions as a strategy for adopting general modes of information processing, showing that people can indeed strategically engage in reflective processing or judge information from a neutral perspective, enabling them to integrate feedback and to reflect more carefully about their decisions in social interactions.

Implementation intentions as behaviour change strategy

The focus of our paper is on experimental research that taps into the consequences of forming implementation intentions and that opens up new fields of applications. As a result, many of the discussed studies revolved around simple and mundane goals, typically provided by an experimenter in the context of rather artificial tasks. But are implementation intentions powerful enough to help people achieve the more momentous goals they personally care about but struggle to attain in everyday life as well? This question has been addressed by researchers around the world, who examined implementation intentions as a behaviour change strategy in an ever-growing number of domains. Meta-analytic evidence from this research suggests that implementation intentions facilitate the attainment of various goals that are relevant for many people but at the same time often notoriously difficult to attain (see Table 7) – such as eating healthy foods, being physically active, and breaking bad habits. The observed effects are typically of medium-to-large size, suggesting that implementation intentions make a noticeable difference. Moreover, implementation intentions can be conveyed as a flexible yet effective meta-cognitive strategy, which allows people to tailor the content of an implementation intention to their personal goals and obstacles (i.e., mental contrasting with implementation intentions, MCII; e.g., Gollwitzer & Oettingen, 2019; Oettingen, 2012, 2014).

Although these findings are encouraging, there is a mismatch between the vast research on such desired effects and the sparse research on potentially undesired effects. This leaves many questions of great theoretical and practical relevance largely unaddressed. For instance, what are the consequences of failing to attain a goal furnished with implementation intentions compared to mere goal intentions? How strongly do people differ in terms of the effectiveness of implementation intentions, and might planning systematically backfire for some people or in some situations? And how can people avoid or deal with undesired consequences of implementation intentions? There are scattered attempts to address some of these questions, for instance, by showing that mindsets adopted in a certain situation modulate implementation intention effects (e.g., Wieber et al., 2014) as well as the alignment of implementation intentions with people's beliefs about the malleability or stability of the to be regulated behaviour (Hirsch et al., 2020). In what follows, we build upon this initial research and discuss how individual and cultural differences might affect implementation intention effects.

Individual and cultural differences in if-then planning

It has been shown that people high in conscientiousness are more likely to enact their intentions (Ajzen et al., 2009) and benefit less from being

Table 7. Overview of Meta-Analyses of the Effects of Implementation Intentions.

Domain	Meta-Analysis	Outcome	Effect Size (d_+)
Affect			
	Webb et al. (2012)[a]	emotion regulation	0.53
(Health) Behaviour			
	Adriaanse, Vinkers, et al. (2011)	dietary behaviour	0.43
	Vilà et al. (2017)	fat intake	0.49
	McWilliams et al. (2019)	smoking cessation	0.29
	Bélanger-Gravel et al. (2013)[a]	physical activity	0.24
	Da Silva et al. (2018)[a]	physical activity	0.25
Cognition			
	Chen et al. (2015)	prospective memory	0.51
Clinical Sample			
	Toli et al. (2016)[a]	multiple	0.99
General			
	Gollwitzer and Sheeran (2006)[a]	multiple	0.65
Meta-analysis of meta-analyses	Keller et al. (in press)		0.54

[a]These analyses were included in the meta-analysis of meta-analyses reported at the bottom of the table (Keller et al., in press).

instructed to make if-then plans than people low in conscientiousness (Webb et al., 2007). One interpretation of these findings is that conscientiousness might be associated with an inclination to use if-then planning to facilitate goal attainment even without prompts to do so. Whether such a general propensity to make if-then plans indeed exists, however, is subject of ongoing research. Specifically, questionnaires begin to emerge that allow to measure planning as a broader facet of conscientiousness (e.g., the planfulness scale; Ludwig et al., 2019) as well as inclinations to engage in if-then planning as a specific self-regulation strategy (e.g., the if-then planning scale, Bieleke & Keller, 2020). Results so far indicate a small-to-medium correlation between conscientiousness and the inclination to use if-then plans as a self-regulation strategy (e.g., $r = .36$; Bieleke & Keller, 2020). As such, research on individual differences in if-then planning forms the basis for more powerful tests of implementation intention interventions by considering pre-existing individual differences as potential moderators of their effects on behaviour. The possibility to determine who might benefit most (or least) from prompts to engage in if-then planning also permits designing interventions that are specifically tailored to individual needs and it allows to track the effects of interventions on people's tendency to engage in if-then planning over time.

In contrast to the growing literature on individual differences in if-then planning, the role of cultural differences has been largely neglected so far. However, there are several ways in which cultural differences likely matter in implementation intention research. First, individuals living in cultures with a low norm-orientation (Oettingen et al., 2008) or with a preference for

avoiding uncertainty (Rauch et al., 2000) perceive planning as more appropriate, facilitating the beneficial effects of implementation intentions on goal attainment. Second, individualistic cultures prioritize the attainment of personal goals, while collectivist cultures focus on group goals (Triandis, 2001), suggesting that implementation intentions geared towards the respective goals are more effective (e.g., with "I"-plans and "We"-plans; Thürmer et al., 2015). Third, people from Eastern cultures adopt more concrete mindsets than people from Western cultures (Nisbett et al., 2001), which should amplify both the benefits of implementation intentions in terms of goal attainment as well as their costs in terms of disregarding alternative non-planned means (Wieber et al., 2014). As plausible as this theorizing seems, to date systematic research on the effects of cultural differences on implementation intentions is still missing.

Research on cognitive processes

It also seems crucial to continue and expand the research on cognitive processes and neurophysiological correlates of implementation intentions effects, which provides valuable insights into the kind of phenomena that can be effectively regulated with implementation intentions (e.g., response inhibition, stereotyping) and helps to determine the conditions under which implementation intentions work best. For instance, in several of the studies that we have discussed above the differences between control and implementation intention instructions were subtle but implementation intentions still turned out to be more effective. All this suggests that the if-then format is crucial for the effectiveness of implementation intentions. To illustrate, consider a study by Chapman et al. (2009) who asked 557 young adults to increase their intake of fruit and vegetables by making plans. Participants who were instructed to use an if-then format realized a 66% larger increase in their subsequent fruit and vegetable intake than participants who were free to use any format they wished. The authors stressed that both conditions "were designed to be as similar as possible with regards to information and examples, with the only difference being the instruction for structuring the plans" (p. 321). But why does the seemingly minor omission of the if-then structure already constitute such an effective control condition?

One explanation is given by cognitive frameworks that relate the effects of implementation intentions to mental simulations (Martiny-Huenger et al., 2017). According to this perspective, perceptual and motor areas in the brain – representing the critical situation and the planned behaviour, respectively – are concurrently activated when people form implementation intentions. This is assumed to create a cerebral blueprint for the behaviour that is then activated again when the critical situation is encountered, which in turn facilitates response initiation in terms of probability and immediacy. Thus,

the importance of the if-then format might be due to the close correspondence of the sequence of events laid out in the verbal if-then plan and the actual if-then sequence of events. Support for this idea comes from Martiny-Huenger et al. (2017), who demonstrated that implementation intentions that imply a certain movement (e.g., "If I see an apple, then I will immediately grab it" implying an elbow flexion) facilitate this movement when the critical stimulus (i.e., an apple) is later encountered. More specifically, they sped up pull responses for virtual apples on a computer screen when having to classify fruits and vegetables by pulling or pushing a joystick. So, the mental simulation account provides one explanation for why even subtle changes in the if-then format constitute suitable control conditions, complements existing theories about implementation intention effects, and provides insights into how if-then planning affects perception and action.

An understanding of such cognitive processes is also important because if-then contingencies are a universal element of how people organize their behaviour, permitting its integration into other research domains. For instance, the effects of mentally simulating certain actions on performance are debated by sport psychologists (e.g., Holmes & Collins, 2001) who might benefit from the observation that their effectiveness hinges on inconspicuous details (such as initial adjustment costs; see Bieleke et al., 2019, for an empirical illustration in the domain of sports). Similarly, cognitive neuroscience distinguishes between proactive and reactive forms of cognitive control (Braver, 2012). Forming implementation intentions might be interpreted as a strategy that allows people to dynamically switch between these forms of control, preparing for a future goal-relevant situation (proactively) to enable automatic responding in situ (reactively).

Integration with adjacent research on behaviour change

Forming implementation intentions is not the only strategy of interest for researchers analysing behaviour change. For instance, some prominent tools are based on the notion of nudging (Thaler & Sunstein, 2009), which describes small alterations in an individual's environment that are (almost) without cost to the individual but promote the attainment of higher-order goals. To illustrate, putting healthy items on the top of the menu (Policastro et al., 2017) or changing whether someone is by default registered as an organ donor (Johnson & Goldstein, 2003) promotes healthier eating and meeting the demand for organs, respectively. We will use the remainder of this review to discuss how research on implementation intentions can be informed by and thereby benefit from research in such related fields of psychology.

Recent research on nudging has revealed some remarkably interesting implications that could greatly benefit research on implementation intentions. For instance, in their study on healthy eating mentioned above, Policastro et al.

(2017) found that participants increased their fibre intake and lowered their sodium intake because they chose healthier ingredients for their sandwiches (e.g., whole-grain bread). Overall calorie intake nevertheless remained steady because participants were now more likely to order condiments (mayonnaise being the main culprit) which attenuated any effect on calorie intake. Participants apparently compensated for the healthier ingredients by choosing other, less healthy ingredients. Avoiding temptations that are rewarding in the short run but impair the attainment of a long-term goal might become even more difficult when initial progress has been made and people feel they have now deserved a reward for showing the wanted goal-directed behaviour. So, after making progress on the goal by ordering whole-grain bread, tasty mayonnaise is seen as a reward and more likely to be ordered.

Such compensatory behaviours have so far not been the focus of implementation intention research but seem conceivable. However, implementation intentions could also be an effective means for counteracting such pitfalls: First, forming implementation intentions raises awareness of the goal one wants to reach and prioritizes this goal over others. Additionally, when an implementation intention concerning the choice of ingredients has been formed (e.g., *"If I choose my bread, then I will always choose whole-grain!"*), choosing various other ingredients for a meal may constitute a situation that is sufficiently similar for which implementation intentions have been shown to generalize (see above). Second, compensatory behaviours are most likely not a planned, conscious choice but an impulsive one. Implementation intentions are highly effective in regulating such automatic and impulsive behaviours (e.g., social projection; A. Gollwitzer et al., 2017). Combined with the research discussed so far, it seems reasonable to assume that a specific mode-of-thought -inducing plan (e.g., *"If I make a choice, then I will think about whether it is in line with my long-term goals"*) can effectively counteract the influence of compensatory behaviours. However, this assertion remains to be tested in future research, likely bringing up further questions at the intersection of nudging and implementation intentions.

Goal striving in teams constitutes another example for how implementation intention research could benefit from other fields of research. Teams face different challenges compared to individuals. For instance, it is questionable whether the defining features of automatic behaviour (Bargh, 1994) also apply to teams and thus whether implementation intentions can strategically automate collective goal striving. Moreover, collective goal striving poses fundamentally different challenges as it is often necessary for individuals to suspend their conflicting individual goals to attain a collective goal, to accept a subordinate role in a hierarchy, or to communicate with each other during goal pursuit. In a series of experiments described above, Thürmer et al. (2017) have shown that teams that formed collective implementation intentions to perform well in a straining endurance task increased their performance

compared to participants forming collective goal intentions. Interestingly, the authors observed that when rendering communication between group members impossible, the increase in performance faded for groups with collective implementation intentions but was still observed for groups whose members each formulated their own individual implementation intention.

Conclusion

As it provides a powerful strategy to effectively narrow the gap between (goal) intentions and behaviours, many researchers have worked on the self-regulation strategy of forming implementation intentions (i.e., if-then plans). Since the publication of Peter Gollwitzer's seminal article on intentions in 1993, this research has addressed a multitude of questions, from examining the kind of problems implementation intentions can tackle to their underlying processes and moderators. All of this has contributed substantially to the understanding of why even people strongly committed to pursue certain goals often fail to act accordingly. Here, we introduced novel research that has investigated the processes underlying implementation intention effects, focusing on both their desired and undesired consequences for goal attainment and physiological correlates. Other research has examined whether implementation intentions promote goal attainment in novel domains, for instance, dealing effectively with perceptions of effort in athletic tasks or with processing available information to make good decisions. At this point, it seems that implementation intentions must be carefully tailored to these different domains, which in turn necessitates further research on their moderators. We have sketched out several lines of future research that we feel might contribute fruitfully to this endeavour.

Funding

This work was supported by the German Research Foundation (DFG) through the research units FOR 1882 "Psychoeconomics„ and FOR 2374 "Riskdynamics„„ and through the research project 441551024 "Updating Risk„.

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