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Committing to implementation intentions: Attention and memory effects for selected situational cues

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Abstract Two studies tested whether forming implementation intentions (Gollwitzer, Am Psychol 54:493–503 in 1999) results in a heightened activation of specified situational cues. Going beyond prior studies, participants of the present studies specified these opportunities on their own (i.e., the action cues were not assigned by the experimenter), and activation level was assessed by attraction of attention and recall performance rather than lexical decisions. In Study 1, situational cues associated with the where and when to act on an everyday life goal attracted more attention than non-specified cues when presented to the non-attended channel in a dichotic listening task. In Study 2, the recall of specified cues was better than that of non-specified cues both 15 min after forming implementation intentions and after a delay of 2 days. Importantly, goal commitment and implementation intention commitment moderated this effect.

Keywords Intentions · Goals · Implementation intentions · Cognitive accessibility · Commitment

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Introduction

There is strong evidence that intentions have a special status in long-term memory, showing greater cognitive accessibility than other memory contents (e.g., Goschke and Kuhl 1993; Koriat et al. 1990; Marsh et al. 1998, 2007). This special status is assumed to be a result of a heightened activation level of intentions compared to other information. Goschke and Kuhl (1993) proposed that this heightened state of activation is stable over time (i.e., intention-superiority effect; ISE; Goschke and Kuhl 1993). This heightened state of activation prior to the completion of an intention can be observed by using various task paradigms, for instance, recognition (e.g., Goschke and Kuhl 1993), lexical decision (e.g., Marsh et al. 1998, 1999), recall (Koriat et al. 1990; Penningroth 2005), and event-based prospective memory tasks (Kazén et al. 2008, Study 1). Badets et al. (2006) were even able to show the special status of intentions in long-term memory in the domain of motor skill learning. The ISE has been observed with experimentally assigned but also everyday intentions being long-term (up to 1 year) and self-set by participants (e.g., Kuhl and Goschke 1994; Maylor et al. 2000). Some authors (e.g., Dockree and Ellis 2001; Förster et al. 2005; Marsh et al. 1999) report that once an intention has been fulfilled or cancelled, the heightened activation is inhibited, leading to lowered levels of activation relative to neutral material (Marsh et al. 1998, 1999). Moreover, the level of activation seems to be positively affected by variables that relate to the person's state of commitment to realize the intention at hand (e.g., the goal's perceived expectancy and value, Förster et al. 2005; a situational necessity to act towards the goal, Moskowitz et al. 2004).

Research on implementation intentions

Gollwitzer (1993, 1999) postulated a distinction between two types of intentions, goal intentions versus implementation intentions. Whereas goal intentions specify an intended behavior or outcome, implementation intentions specify a cue (i.e., an external situation or an inner state in the if-component; Achtziger et al. 2008) that is then linked to a behavior that is instrumental to reaching the goal described in the goal intention (i.e., a goal-directed response in the then-component). Thereby, a strong link between the if- and the then-component is established that generates the positive effects of these action plans on goal attainment. Research on implementation intentions has shown (summaries by Gollwitzer and Sheeran 2006; Achtziger and Gollwitzer 2010) that implementation intentions formed in the service of goal intentions enhance goal attainment. Action initiation in the presence of the specified cues is observed to be immediate (Gollwitzer and Brandstätter 1997), efficient (Brandstätter et al. 2001), and does not require a further conscious intent (Bayer et al. 2009).

In line with the findings of ISE research, implementation intention theory (Gollwitzer 1993, 1999) postulates that specifying critical cues in the if-component of implementations intentions causes the representation of these cues to become highly activated and thus more accessible than alternative cues. Various findings support this assumption. Webb and Sheeran (2004), Study 1 showed that implementation intentions increase the likelihood to detect a specified cue. In their study the implementation intention was geared at supporting the detection of the letter *F* in a text, and accessibility was indicated by the number of capital *F*s participants could detect. Implementation intention participants were better in detecting the letter *F* than control participants. It was concluded that forming an implementation intention heightens the cognitive activation of the if-component, and consequently the specified cue is more easily detected compared to other cues. Parks-Stamm et al. (2007, Study 1) observed that the increased accessibility of specified cues is accompanied by a decreased accessibility of alternative unspecified cues. In a word identification task, implementation intention participants were better at recognizing the words specified in an implementation intention than control participants (i.e., participants with a mere goal intention); in contrast, their identification performance for alternative, non-specified words was lower than that of control participants. Further studies revealed that the words used to specify the situational cue in the if-component of an implementation intention are associated with speeded responses in a subsequent lexical decision task; this speed-up effect was also found to mediate the positive implementation intention effect on realizing the response specified in the then-component (Aarts et al. 1999; Webb and Sheeran 2006, 2008).

The present research

Because forming an implementation intention implies the conscious selection of a critical situation or stimulus as the if-part of the implementation intention, the mental representation of this situation is assumed to be highly activated and thus easily accessible (Gollwitzer 1999). This heightened cognitive accessibility makes it easier for people to detect and attend to the critical situation in the surrounding environment, even when they are busy with other things. At the same time, it facilitates the recall of the critical situation in terms of how, where, and when the goal-directed behavior is to be enacted. Both processes are highly important for processes of goal striving. For instance, missing viable opportunities to act due to being distracted is one of the most often reported reasons for failing to attain one's goals (see Gollwitzer and Sheeran 2006). Similarly, prospective memory research has consistently shown that long-term memory for one's goals and plans determines whether a goal will be attained at all (e.g., Goschke and Kuhl 1993).

In accordance with these considerations, Study 1 of the present research investigated whether cues specified in implementation intentions draw more attention than alternative, non-specified cues in a dichotic listening task (e.g., Cherry and Taylor 1954; Nielson and Sarason 1981; Treisman 1960). We predicted that specified cues to act on will draw more attention than alternative (i.e., non-specified) cues in implementation intention participants. In yoked control participants who only familiarized themselves with the critical cues, no such attention drawing effects should be observed. Moreover, implementation intention participants should show stronger attention drawing effects on specified cues than the (yoked) control participants. These predictions were based on the assumption that a heightened activation of the critical cues should only be generated by specifying them in the if-components of implementation intentions, whereas familiarizing oneself with these cues should not suffice. Note that in this study words were used as critical targets that were idiosyncratically specified by the implementation intention participants themselves. This goes beyond earlier research on the heightened accessibility of action cues specified in action plans (e.g., Aarts et al. 1999; Parks-Stamm et al. 2007). Moreover, earlier research only used lexical decision tasks in order to test the heightened accessibility of action cues. Of course this is one possibility to test this cognitive consequence of implementation intention formation, but there are also other methods that are well suited to measure accessibility. Therefore, adhering to a multi-method approach we tested cognitive accessibility in Study 1 by means of a dichotic listening task.

Study 2 examined the cognitive accessibility of selected cues by still another method, that is, via recall performance of these cues as compared to offered alternative, but non-selected cues. A notable strength of Study 2 lies in the variation of the length of the retention interval. Only a very few studies investigated whether memory for intentions is influenced by the delay between forming the intention and its execution. For instance, Hicks et al. (2000) investigated in 5 event-based prospective memory studies the importance of the retention interval. Another aspect that distinguishes Study 2 from earlier research is the fact that we manipulated participants' commitment on their implementation intentions and tested whether this manipulation affects long-term memory for the specified cues. So far implementation intention research has only focused on goal commitment as a potential moderator of implementation intention effects on goal attainment (e.g., Sheeran et al. 2005), and the strength of goal commitment in these studies was only been measured and not manipulated. We predicted that if the superordinated goal intention is deactivated or if participants are only weakly committed to perform their implementation intentions, differences between critical and alternative cues should no longer be observed in a recall test as the heightened accessibility of critical cues should have vanished. To test the impact of commitment on the heightened activation of action cues, the recall of cues specified in implementation intentions was tested either 15 min after the formation of the implementation intentions or after a delay of 2 days. The delayed recall test was conducted to critically test the assumption that the state of heightened activation persists over time.

Study 1: Disruption of focused attention

We investigated whether situational cues specified in implementation intentions draw more attention than alternative, non-specified cues. As experimental paradigm a dichotic listening task was used (e.g., Broadbent 1954; Bryden 1988; Cherry and Taylor 1954; Nielson and Sarason 1981; Treisman 1960), and the critical cues were presented to the non-attended channel. We predicted that cues specified in implementation intentions should draw more attention in a dichotic listening task than non-specified alternative cues, as measured by a reduced shadowing performance of information presented to the attended channel. In yoked control participants who familiarized themselves with the critical cues, no such attention drawing effects should occur. These predictions were based on the assumption that a heightened activation of the critical cues should only be generated by specifying them in the if-component of implementation intentions, whereas merely familiarizing oneself with these cues should not suffice.

Participants were invited to take part in allegedly two studies. In the first study, implementation intention participants were asked to name a goal that is not easily achieved (i.e., requires more than four action steps and that these steps in addition should be quite complex) and which they intended to realize within the next 3 months. We asked to name a goal that is quite difficult to be reached to ensure that participants would not be able to attain their goal within the next couple of days (i.e., stay active) and to avoid that they already had some concrete ideas about the exact route of realizing this goal. In addition, they were asked to plan goal realization by forming several implementation intentions by filling out a questionnaire. Each control participant was matched to an implementation intention participant (i.e., yoked). Control participants were required to judge the layout of the implementation intentions questionnaire and to write down the words describing their yoked partners' implementation intentions, this way increasing familiarity with these words.

The allegedly second study was run the next day. All participants were asked to perform a dichotic listening task. They repeated (i.e., shadowed) words presented to the attended channel. Words presented to this channel were not associated with the words specified in the if-component of the implementation intentions. Words presented to the unattended channel, however, were taken from the if-components of the implementation intentions (i.e., critical words). Other words also presented to the unattended channel were not related to the if-component of the implementation intentions (i.e., non-critical words). As dependent variables, pronunciation errors and latencies for the targets presented to the attended channel were recorded.

For the implementation intention condition, it was predicted that the heightened activation of the critical words presented to the unattended channel should interfere with shadowing the words presented to the attended channel. In other words, a shift of attention from the targets presented to the attended channel to the critical targets presented to the unattended channel was expected in this condition. This shift should be indicated by slower shadowing latencies (e.g., Lewis 1970; Treisman 1974) and more errors (e.g., Dawson and Schell 1982; Nielson and Sarason 1981) whenever critical words but not when non-critical words were presented to the unattended channel. No such effects were expected in the control condition.

Methods

Participants

Male university students participated in the experiment (n = 32; age: $M = 24.91$, SD = 3.17). Participants were enrolled in different fields of studies. They were recruited

by telephone for (allegedly) two different experiments and randomly assigned to the two conditions.

Design

The study followed a 2 between (planning: control vs. implementation intention) × 2 within (Target Words: critical vs. noncritical) mixed-model design. For counterbalancing reasons, participants were randomly assigned to a left versus right ear condition (i.e., the target words were either presented to the left or right ear). As dependent variables pronunciation latencies and pronunciation errors of words presented to the attended channel were measured.

Procedure

Participants were told that the two studies would be scheduled 24 h apart. The first study was described as a study about how people organize their everyday life, the second study as investigating auditory vigilance. Different experimenters were named as responsible for the two studies to confirm that the two studies would be independent from each other.

In the implementation intention condition of the (allegedly) first study, participants arrived at the laboratory and named a goal that they intended to realize within the next 3 months. They were told that this goal should fulfill the following criteria: (1) it concerns an issue that they already had considered for a while, (2) its realization can be broken down into several steps, (3) the consequences of goal attainment are highly appreciated, and (4) it can be reached in the next 3 months. These criteria should ensure that no over-learned, habitual goals were named. After naming their goal, participants answered five questions about their commitment to this goal on 10-point scales (0 = *not important/not at all* to 9 = *very important/very much; see below*).

Afterwards, implementation intention participants were told that they should plan the implementation of their goal and were given an example on how to do this (i.e., plan a trip to Australia). Then, they named five goal-directed behaviors suited to support the realization of their goal and listed them on a sheet of paper. For each of these behaviors, participants were asked to form implementation intentions by writing down where and when (i.e., the if-components) they planned to perform each of them (see also Gollwitzer and Brandstätter 1997; Sheeran and Orbell 1999). Hereafter participants rated their implementation intention commitment (see below).

Each participant in the control condition was randomly assigned to one of the implementation intention participants (i.e., yoked design). They received the completed questionnaire of their yoked partner and were asked to judge its layout and to copy the words of the presented implementation intentions. Thereby, control participants were made familiar with the words used by implementation intention participants, controlling for salience effects of the critical words in the dichotic listening task. Next day, all participants were seated in individual cubicles where the words were presented by means of headphones simultaneously to their left and right ears. Participants repeated as quickly as possible the words that were presented on either their left (or right) ear (attention to the channels was counterbalanced). The computer recorded pronunciation latencies on the presented words of the shadowed channel from the beginning of the presentation of the word until the beginning of the response. No responses and wrong responses (i.e., pronouncing a different word, pronouncing the word only partially or jolty) were defined as errors by independent raters listening to the voice recorded sessions.

Simultaneously to the dichotic listening task, participants performed a probe reaction time task, in which they pressed a button as quickly as possible whenever a light went on at random times. The experimenter emphasized that this task was only secondary in importance. It was added to prevent participants from listening to the unattended channel. There were no differences between probe reaction times in the implementation intention condition and the control condition ($F < 1$). All participants were told that there would be five word lists to repeat, starting with a practice list. After the dichotic listening task had been completed, participants were asked whether they noticed the presentation of familiar words on the nonattended channel. None of the participants reported having noticed words describing action cues which they had named (implementation intention condition) or copied (control condition) the day before. Then, participants were carefully debriefed, thanked, and paid (10 Euros).

Material

Target words For each implementation intention participant, 10 words (nouns) were randomly selected from their implementation intention questionnaire. These critical words described the if-components of their implementation intentions in the dichotic listening task. For example, a participant who intended to buy a bed named as the following critical situational cues: bed, furniture, shop, car, decision, bedroom, ads, credit card, salesperson, and tool. These cues were associated (by participants themselves) with goal-directed actions. Exemplary implementation intentions for the bed buying goal intention read like this: "If the salesperson walks up to me, then I will ask her for the price of the bed that interests me most!" and "And if my car turns out to be too small for transporting the bed, then I'll call my friend for help!" Two matched word lists

were constructed, consisting of 98 nouns each. Words were taken from a German dictionary of word frequencies (Ruoff 1981). They had one to six syllables. Only words that were evaluated as neither positive nor negative in a pretest were selected (e.g., countryside). Word pairs were constructed by matching the critical words with words that had the same number of syllables and frequency of occurrence. All participants were presented the same words. Both words of a word pair were presented at the same moment.

Word lists were prepared in advance, with the exception of the critical words, which were inserted separately for each implementation intention participant and their yoked control participant prior to the experiment. Both words of a word pair were presented at the same moment.

Trials Word pairs were presented in five lists, with a 3 s break between them. At the onset of each list "Achtung" ("attention") was simultaneously presented to both ears. The ITI between the presentations of the words was 1 s. The first list was a practice list of 30 word pairs. The other four lists consisted of 17 word pairs each, whereby in the first and third list critical targets were interspersed (i.e., critical lists). Both critical lists contained 10 critical targets and 7 non-critical targets that were presented to the unattended channel. The critical targets were presented in a randomized order.

Commitment variables Participants answered the following questions right after they had named their goal and formed implementation intentions. The goal commitment items were: (1) How important is this goal compared to your other goals at the moment? (2) How strongly are you determined to realize your goal? (3) How strongly are you committed to realize your goal? and (4) How important is the attainment of your goal to you? Concerning implementation intention commitment, the following question had to be answered: "How strongly are you committed to perform the listed goal-directed behaviors as soon as the specified situations occur?" All answers were given on 10 point-scales (ranging from 0 = *not at all* to 9 = *strongly*). Control participants did not answer these questions as they were not required to name a goal and to plan out its implementation.

Results

Commitment variables

Answers to the goal commitment questions were highly inter-correlated (Cronbach's *alpha* = .79). The overall mean of the answers to these questions was high ($M = 6.58$; SD = 1.41). The implementation intention commitment was high as well ($M = 6.35$, SD = 1.28).

Outliers

Pronunciation latencies were screened for outliers; latencies of less than 400 ms and more than 2,000 ms were excluded (see e.g., Smith 2010; Bargh and Chartrand 2000). Next, latencies of wrong responses (i.e., pronouncing a different word or pronouncing a word partially or jolty) and latencies of more than 3 standard deviations above/below mean were excluded from the data set. Participants who had more than 20% missing data due to these exclusions were eliminated from the data analyses (i.e., 3 participants, leaving a total of 29 participants in the data set). Testing whether there were effects of the location of the attended channel (left vs. right) revealed no significant effects (all Fs < 1).

Shadowing latencies

For each participant, mean pronunciation latencies on the shadowed words were computed separately for trials in which critical and non-critical targets were presented to the unattended channel. A 2 within (target words: critical vs. non-critical) × 2 between (planning: control vs. implementation intention) mixed-model ANOVA on these latencies revealed a significant main effect of target words indicating that latencies on the shadowed words were generally longer when critical targets compared to non-critical targets were presented to the unattended channel, $F(1,27) = 7.22$, $p < .05$, $\eta^2 = .21$. The factor planning did not reach significance, $F(1,27) = 2.39$, $p = .13$, $\eta^2 = .08$ (see Fig. 1). Most important, we observed a significant Target Words × Planning interaction effect, $F(1,27) = 5.06$, $p < .05$, $\eta^2 = .16$.

As predicted, planned t-tests revealed that shadowing latencies were slower when critical targets were presented to the unattended channel in the implementation intention condition ($M = 1{,}121$, SD = 124.19) compared to the control condition ($M = 1{,}040$, SD = 93.89), $t(27) = 1.93$, $p = .05$, $d = .73$. However, there was no difference between implementation intention ($M = 1{,}058$, SD = 86.53) and control participants ($M = 1{,}034$, SD = 78.96) on shadowing latencies when non-critical targets were presented to the unattended channel, $t < 1$. Moreover, implementation intention participants' shadowing was slower when critical targets compared to non-critical targets were presented to the unattended channel, $t(13) = 3.05$, $p < .01$, $d = .58$. This effect was not observed for control participants, $t < 1$.

Errors

A 2 within (target words: critical vs. noncritical) × 2 between (planning: control vs. implementation intention)

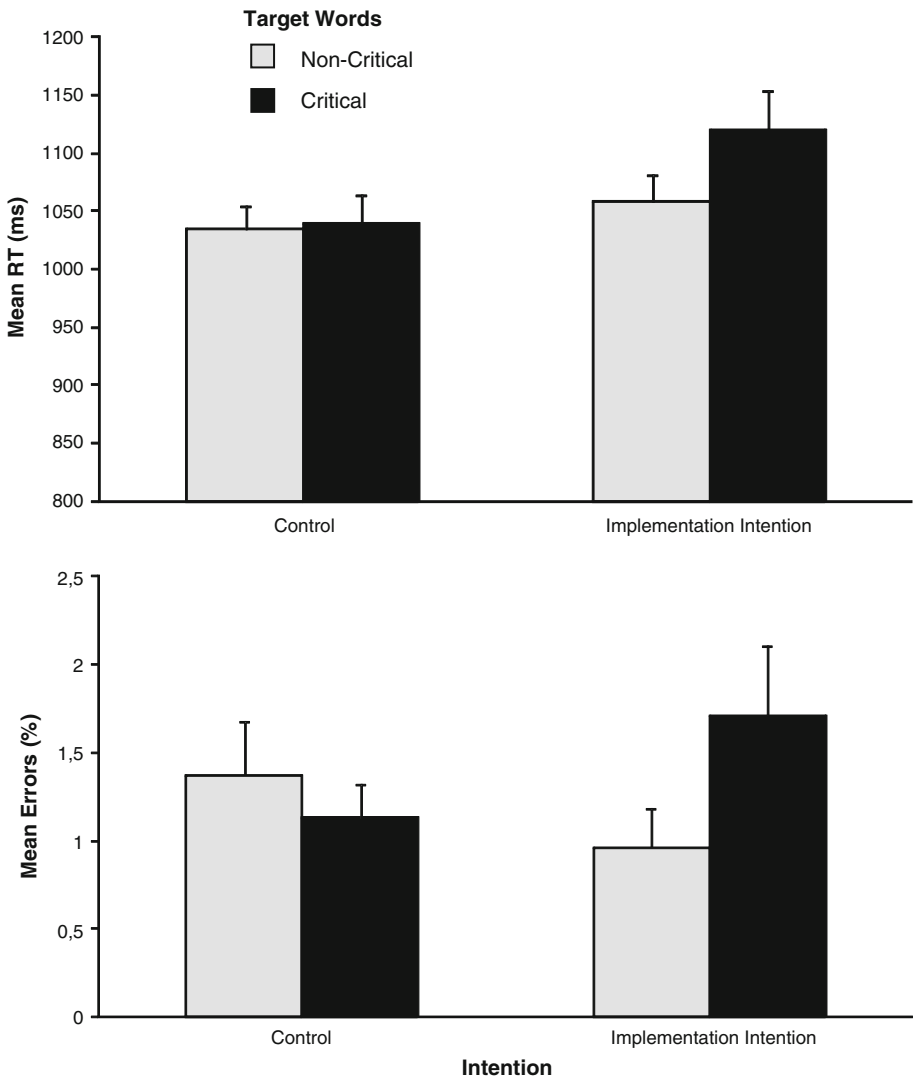

Fig. 1 Mean latencies and errors on the critical and non-critical targets by intention (Study 1)

mixed-model ANOVA on the number of errors in the shadowing task revealed a significant Target Words × Planning interaction effect, $F(1,27) = 4.22$, $p = .05$, $\eta^2 = .14$; no significant main effects merged for target words and planning (all $Fs < 1$).

Planned *t*-tests revealed that implementation intention participants made more errors in the shadowing task if critical targets ($M = 1.71$, SD = 1.49) were presented to the unattended channel compared to non-critical targets ($M = 0.96$, SD = 0.84), $t(13) = 2.24$, $p < .05$, $d = .62$. This difference was not significant for control participants ($M = 1.37$, SD = 1.20 vs. $M = 1.13$, SD = 0.74), $t < 1$. No further comparisons reached significance.

Discussion

Shadowing latencies were assessed as an indicator of attention being attracted to the unattended channel. In the implementation intention condition, the presentation of specified cues to the unattended channel led to significantly longer shadowing latencies compared to the presentation of non-critical targets. No such effect was observed with control participants who had been made familiar with the critical cues due to a yoked familiarization manipulation. Implementation intention participants also showed longer shadowing latencies than control participants when critical cues were presented to the unattended channel, whereas no difference between implementation intention and control participants was observed when non-critical targets were presented. The observed pattern of shadowing latencies strongly suggests that forming implementation intentions make cues specified in the if-components attract attention.

The assessed pronunciation errors were also in line with our predictions. Implementation intention participants revealed a greater number of shadowing errors when critical targets were presented to the unattended channel as compared to non-critical targets. This result was not observed for control participants. Implementation intention participants

did not make significantly more shadowing errors than control participants when critical targets were presented to the unattended channel, however. This suggests that shadowing latencies were a more reliable measure of attending to the critical words than shadowing errors.

The observed pattern of shadowing performance also suggests that implementation intention participants did not become aware of their if–then plans when being distracted by the critical words presented to the unattended channel. If this had been the case, implementation intention participants should have shown some general slowing in shadowing performance (i.e., even when non-critical target words are presented). It seems likely that the attention attraction effects of cues specified in implementation intentions occur outside a person's awareness as well. At least this is suggested by the attention attraction studies reported by Wieber and Sassenberg (2006). Using the flanker task paradigm (Erickson and Erickson 1974), they observed that participants failed to disengage from their implementation intentions when performing a subsequent task—even though the implementation intentions' attention attraction effect had apparently hindered task performance on the prior task (i.e., the flanker task). The authors interpret this finding to mean that participants were not aware of the attention attraction effect of their implementation intentions otherwise they would have revised their implementation intentions.

It is important to note that in the present study words were used as critical targets that were idiosyncratically specified by the implementation intention participants themselves. As these implementation intentions also pertained to everyday life kind of goals, this attests strong ecological validity to the present findings and goes beyond earlier research on the heightened accessibility of cues specified in if–then plans (e.g., non-words such as *avenda*; Webb and Sheeran 2006). Moreover, our findings suggest that the attention drawing effect of cues specified in implementation intentions is quite strong. Early experiments on dichotic listening (e.g., Cherry 1953; Moray 1959) observed that only very little is processed of words presented to the unattended channel. Participants often cannot report any of the words presented to the unattended channel, even if these words have been presented repeatedly (Treisman 1960; Cherry 1953). Due to this strong evidence for the difficult processing of words presented to the to-be-ignored (i.e., unattended) channel in dichotic listening tasks, it is especially impressive that cues specified in implementation intentions are able to draw attention to the unattended channel. Moreover, as we tested attention attraction by these cues in a completely different task than the one in which participants formed their implementation intentions, it can also be assumed that participants were unlikely to be monitoring the appearance of target cues in the dichotic listening task.

Finally, the observed effects seem to be rather stable over time. Note that implementation intentions were formed 1 day prior to performing the dichotic listening task. One might wonder why we did not witness the right ear advantage (REA) which is often found in dichotic listening tasks. The REA usually is interpreted as an indicator of left hemisphere processing superiority of verbal stimuli (e.g., Gadea et al. 1997; Sætrevik and Hugdahl 2007). However, in studies in which the presentation of the words was preceded by primes (Sætrevik and Hugdahl 2007), no REA was observed. Therefore, it can be assumed that if stimuli are presented that are relevant to participants (i.e., implementation intention participants in the present study) or with which participants are familiar (i.e., control participants in the present study), the REA will not occur.

Future research may want to explore the issue of awareness more directly by explicitly asking participants about experienced difficulties in staying concentrated on the attended task. Moreover, it might also want to address the question of whether the attention attraction effect triggered by implementation intentions is primarily based on the fact that attention is readily captured by the critical cues or else caused by delayed disengagement of attention from these cues. To differentiate between these two possible underlying processes it seems necessary to employ task paradigms such as the spatial cueing task (Vogt et al. 2010) or the dot probe task (MacLeod et al. 1986).

Despite these interesting and important results, Study 1 of course also has some limitations. First, the sample of the study was quite small and only male students were included; accordingly, future studies might want to work with larger samples containing male and female participants. Also, one might ask why we did not establish a goal intention condition as is done in other implementation intention studies. In the present study, real life goals and self-chosen implementation intentions were used. Moreover, a yoking procedure was employed to check the heightened accessibility of selected situational cues in the implementation intention group. If we had provided mere goal intention participants with the yoked cues (i.e., the cues specified by implementation intention participants) this would certainly have led to the spontaneous formation of respective implementation intentions in mere goal participants, and thus the mere goal intention group would not have qualified anymore as a control group (Gollwitzer 1999). Finally, Study 1 does not vary commitment to the chosen implementation intentions; we address this issue in Study 2.

Study 2: Long-term memory for specified cues

This study examined the postulated heightened cognitive accessibility of the if-components of implementation

intentions different to Study 1. As heightened cognitive accessibility is known to facilitate recall (e.g., Spranger et al. 2008), we used a free recall procedure to check on the heightened cognitive accessibility of cues specified in implementation intentions. For implementation intention participants we expected an improved recall performance for selected cues as compared to non-selected cues. To check on the postulated temporal stability of the heightened cognitive accessibility, the free recall test was applied either after 15 min of implementation intention formation or with a delay of 2 days.

Moreover, Study 2 addresses two potential moderators. First, as implementation intention effects on goal attainment have been found to depend on the strength of the commitment to the super-ordinate goal (Sheeran et al. 2005), we hypothesized that people still need to feel committed for the expected improved recall for selected cues to occur. Accordingly, we encouraged one group of participants to disengage from the super-ordinate goal; for this group the selected cues were no longer expected to show a recall advantage. Also, Study 2 explored whether commitment also operates as a moderator at the level of the implementation intentions themselves. For this purpose, we varied whether participants felt that they benefit from sticking to their if–then plans (high implementation intention commitment) or not (low implementation intention commitment). We expected that recall advantages for specified cues would only emerge for participants with a high implementation intention commitment.

Finally, all participants were asked to recall as many of the offered options to play the game as possible, either 15 min or 2 days later. A recall advantage for chosen options as compared to non-chosen ones was expected for high implementation intention participants only, given that they had not yet disengaged from the super-ordinate goal of playing the game.

Methods

Participants

Participants were male university students enrolled in different fields of study (n = 120; age: $M = 25.6$, SD = 3.5). We randomly invited half of them to take part in (allegedly) two experiments run on the same day, and the other half to take part in (allegedly) two experiments being run 2 days apart.

Design

The study followed a 2 within (Options: chosen vs. non-chosen) × 2 between (Delay of Recall: 15 min vs. 2 days) × 3 between (Commitment: low implementation intention commitment vs. high implementation intention commitment vs. goal disengaged) mixed model factorial design. As the dependent variable the free recall of target words was measured 15 min or 2 days after implementation intentions formation.

Procedure

Participants arrived at the laboratory and completed a questionnaire on how they organized their everyday life. Then, participants were informed that the aim of the study was to evaluate a new type of game therapy geared towards increasing self-efficacy. Two games were said to be developed. One was a computer game that demanded to respond differently to the presentation of critical stimuli (i.e., various presented characters) by pressing specified response buttons (i.e., approach, avoidance). The second was a handicraft game that demanded creating different objects (e.g., a house) by assembling various provided materials (e.g., wooden blocks). Participants indicated whether they would like to play these games and formed the goal intention "I want to play these games!" Then, they planned in detail when and where to play the games (see also Gollwitzer and Brandstätter 1997; Sheeran and Orbell 1999). Pairs of situational cues were presented on a computer screen and participants chose an option specifying when and where they intended to play the games. It was emphasized that participants would only plan where and when to play the games now, but that these games would be played later. After the planning task participants were told that they would be contacted again to arrange an appointment for a second session in which the games would actually be played.

Thereafter, (allegedly) based on their answers to the daily management of one's life questionnaire (e.g., how often they performed leisure activities, whether they arranged their activities on a weekday differently as compared to the weekend) we manipulated participants commitment (see below). Two-thirds of the participants were told that they qualified as somebody who benefitted much from sticking to plans (high implementation intention commitment condition), whereas one-third was told that they benefitted much from staying flexible regarding their plans (low implementation intention commitment condition). Then, participants indicated their implementation intention commitment and the plausibility of this feedback (see "Materials" section below). Control participants did not have to answer these commitment questions.

A concentration test (Düker 1953) was handed out as a distraction task in which a series of arithmetic problems had to be solved. Establishing a disengagement from the goal intention, half of the high implementation intention commitment participants were informed in the middle of

this task that the games would not have to be performed as already enough data had been collected. Then, participants performed the rest of the concentration test.

At the end of the test (about 15 min after forming implementation intentions), for one half of all participants a free recall test was administered in the context of the (ostensibly) second experiment. Participants were asked to write down as many of the options of playing the two games as possible. All other participants were told that the second experiment was conducted 2 days later, not being informed that they would then be asked to recall the options to play the games. This was done to prevent them from a recall of the options in the meantime. Participants were debriefed, thanked, and paid once they had completed the recall test (five Euros for each session).

Materials

Life organization questionnaire It (allegedly) investigated how everyday life is organized. Participants reported on different issues concerning their leisure activities (e.g., the time they reserved for leisure activities or whether they arranged their activities on a weekday differently as compared to the weekend, etc.).

Offered options to play the games These situational cues were presented as answers to questions for each of the two games. Altogether 9 options of playing each game were chosen by participants themselves. For example, specifications for the computer game were "Where will you play the game?" (Options: a. laboratory, b. home office); "When will you play it?" (Options: a. Monday, b. Thursday); "Which set-up will you use?" (Options: a. mouse, b. joystick).

Manipulation check The implementation intention commitment questionnaire asked: "How strongly are you determined to play the games under the conditions you have selected?", "How important is it for you to play the games under the conditions you have selected?", and "How committed are you to play the games under the conditions you have selected?" Participants marked their answers on 10 point-scales ranging from zero (*not determined/not important/not committed at all)* to 9 *(very determined/very important/strongly committed*). The perceived plausibility of the feedback was checked with the following item: "Are the results of the questionnaire on life organization in accordance with your own experiences?"

Free recall questionnaire Participants were asked to recall all of the offered options of playing the games (i.e., even the options which they did not choose for themselves). They were asked to stop with this recall if and only if they would actually not be able to recall any more options.

Results

Manipulation check

Answers to the feedback plausibility question did not reveal significant differences between the commitment conditions, $F(1,118) = 1.59$, $p = .21$, $\eta^2 = .01$. This suggests that both the low and the high implementation intention commitment induction were equally well accepted. As the answers to the implementation intention commitment items showed high intercorrelations (Cronbach's *alpha* = .76), an index was computed by taking the mean. A Commitment × Delay of Recall ANOVA on this index revealed a significant main effect of Commitment, $F(2,114) = 7.93$, $p < .001$, $\eta^2 = .12$. Comparing the means of low implementation intention commitment participants ($M = 3.29$, SD = 1.76) with that of high implementation intention commitment participants ($M = 4.15$, SD = 2.06) revealed that the expected difference was significant, $t(78) = 2.00$, $p < .05$, $d = .45$. Also, low implementation intention commitment participants ($M = 3.29$, SD = 1.76) reported lower commitment than high implementation intention commitment but goal disengaged participants ($M = 5.06$, SD = 2.06), $t(78) = 4.12$, $p < .001$, $d = .92$. This is in agreement with the fact that the implementation intention commitment measure was taken prior to the disengagement manipulation.

Free recall

A mixed-model 2 within (Options: chosen vs. non-chosen) × 2 between (Delay of Recall: 15 min vs. 2 days) × 3 between (Commitment: low implementation intention vs. high implementation intention vs. goal disengaged) ANOVA on number of remembered options was computed. A significant Options × Commitment interaction, $F(2,114) = 6.98$, $p < .01$, $\eta^2 = .11$, a significant main effect of Options, $F(1,114) = 21.16$, $p < .001$, $\eta^2 = .16$, and a significant main effect of Delay of Recall was observed, $F(1,114) = 65.98$, $p < .001$, $\eta^2 = .37$. No other main or interaction effects reached significance (Options × Delay of Recall × Commitment interaction, $F < 1$; Options × Delay of Recall interaction, $F(1,114) = 2.61$, $p = .11$, $\eta^2 = .02$; main effect of Commitment, $F(1,114) = 2.09$, $p = .13$, $\eta^2 = .03$; (see Fig. 2). Due to the significant main effect of Delay of Recall and as we intended to test whether we still can observe a memory advantage for specified action cues after 2 days, we computed 2 (Options) × 3 (Commitment) ANOVAs on the number of recalled options for each delay period separately.

Free recall after a delay of 15 min For the options recalled after 15 min, a significant Options × Commitment interaction, $F(1,57) = 3.19$, $p < .05$, $\eta^2 = .10$, and a significant main effect of Options was observed, $F(1,57) = 5.61$, $p < .05$, $\eta^2 = .09$. The main effect of Commitment did not reach significance, $F(2,57) = 1.49$, $p = .23$, $\eta^2 = .05$. Planned *t*-tests revealed that high implementation intention commitment participants showed a better recall of the chosen options ($M = 7.20$, SD = 2.12) compared to the non-chosen options ($M = 6.20$, SD = 1.85), $t(19) = 3.68$, $p < .01$, $d = .50$, whereas low implementation intention commitment participants did not ($M = 5.90$, SD = 1.55 vs. $M = 5.75$, SD = 1.71), $t < 1$. The same was true for the disengaged participants ($M = 5.90$, SD = 2.20 vs. $M = 5.85$, SD = 1.98, $t < 1$). Thus, as early as 15 min after implementation intention formation participants who were highly committed to their implementation intentions were better in the recall of selected options compared to non-chosen cues. However, if this implementation intention commitment was rather low or participants were induced to disengage from the super-ordinate goal, the selected options were no longer remembered better than their non-selected alternatives.

Moreover, high implementation intention commitment participants ($M = 7.20$, SD = 2.12) showed better recall of the chosen options than both low implementation intention commitment participants ($M = 5.90$, SD = 1.55), $t(38) = 2.21$, $p < .05$, $d = .70$, and disengaged participants ($M = 5.90$, SD = 2.20), $t(38) = 1.91$, $p < .05$, $d = .60$ (*one-tailed*). The recall performance of the low implementation intention commitment and the disengaged participants was similarly weak, $t < 1$. Finally, there was no difference between the commitment conditions with respect to the recall performance for non-chosen options, all *t*s < 1. Thus, after a delay of 15 min high implementation intention commitment participants were significantly better in the recall of the chosen options compared to participants who showed only a low commitment to their implementation intentions. A similar pattern of results occurred when comparing the recall of chosen options in participants who were disengaged from their super-ordinate goal with the recall of participants with a high commitment to their implementation intentions that

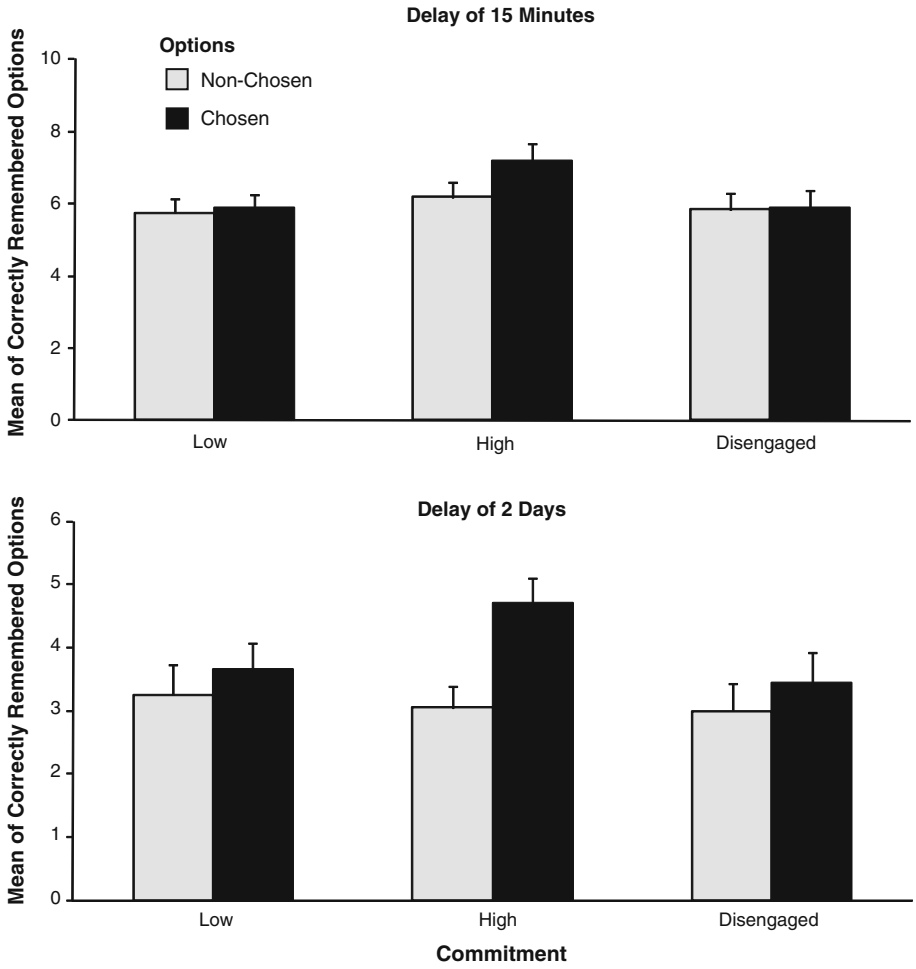

Fig. 2 Mean numbers of correctly remembered options by commitment and delay (Study 2)

were still engaged with their super-ordinate goal. The latter group of participants outperformed disengaged participants in the recall of the chosen options. Thus, among participants who were initially highly committed to their implementation intentions, but who were then induced to disengage from the super-ordinate goal, the same weak recall performance of selected action cues (i.e., chosen options) was found as with low implementation intention commitment participants.

Free recall after a delay of 2 days Analogous analyses were computed for participants' recall performance 2 days after they had formed their implementation intentions. An Options × Commitment ANOVA on the number of options remembered uncovered a significant interaction effect, $F(2,57) = 3.85$, $p < .05$, $\eta^2 = .12$, and a significant main effect of Options, $F(1,57) = 16.02$, $p < .001$, $\eta^2 = .22$. The factor Commitment did not reach significance, $F < 1$. The analysis of the Options × Commitment interaction by means of planned *t*-tests revealed that high implementation intention commitment participants who were still engaged with the super-ordinate goal showed better recall of the chosen options ($M = 4.70$, SD = 1.78) compared to the non-chosen options ($M = 3.05$, SD = 1.54), $t(19) = 5.18$, $p < .001$, $d = .99$. As expected, low implementation intention commitment participants showed no better recall of the chosen options compared to the non-chosen options (chosen options: $M = 3.65$, SD = 1.87; non-chosen options: $M = 3.25$, SD = 2.15), $t(19) = 1.09$, $p = .28$, $d = .19$. The same was true for participants who initially were highly committed to their implementation intentions but who disengaged from the super-ordinate goal (chosen options: $M = 3.45$, SD = 2.09; non-chosen options: $M = 3.00$, SD = 1.96), $t(19) = 1.14$, $p = .27$, $d = .22$.

In other words, analyzing the data of participants who had a highly delayed recall (after 2 days), we observed a similar pattern of results as with participants in the 15 min delay condition. Participants who were highly committed to their implementation intentions (and still engaged with the super-ordinate goal) were better in the recall of chosen options (i.e., selected action cues) compared to non-chosen options. However, if implementation intention commitment was rather low or participants were induced to disengage from their super-ordinate goal, the selected options were no longer remembered better than the non-selected alternatives.

Furthermore, we observed that high implementation intention commitment participants showed better recall for chosen options ($M = 4.70$, SD = 1.78) than both low implementation intention commitment participants ($M = 3.65$, SD = 1.87), $t(38) = 1.82$, $p < .05$, $d = .58$ (*one-tailed*), and disengaged participants ($M = 3.45$, SD = 2.09), $t(38) = 2.04$, $p < .05$, $d = .64$. There was no difference in recall for chosen options between the low implementation intention commitment and disengaged participants, $t < 1$. Finally, there were no differences between the three commitment conditions in recall of the non-chosen options (all *t*s < 1; see Fig. 2). This pattern of results was in accordance with our predictions and with our observations of the recall performance after a delay of 15 min. Even if the recall test was run 2 days after the selection of action cues, high implementation intention commitment participants were significantly better in recalling their chosen options compared to participants who showed only a low commitment to their implementation intentions. The same was true when comparing the recall of action cues in participants who were disengaged from the super-ordinate goal with that of participants with a high commitment to their implementation intentions (i.e., who were not disengaged). The latter group of participants outperformed disengaged participants in the free recall of their chosen options. Thus, also for a strongly delayed recall of action cues (i.e., after 2 days) a state of heightened activation could be observed that did not emerge for participants who already disengaged from their goal intention or who were not highly committed to their action plans. Such moderation effects by manipulated commitment to goals and plans have not been reported by earlier research on the accessibility of action cues specified in implementation intentions.

Discussion

It is unlikely that the observed pattern of results is due to differential rehearsal as the distracter task applied after the formation of the implementation intentions should have prevented any rehearsal. Research on rehearsal has shown in general that the spontaneous rehearsal of information that is not expected to be asked for in a later recall test (i.e., the recall request is incidental) is very unlikely. This is especially true if a distraction task is applied immediately after the encoding of the information (e.g., Wixted 1992) as was the case in the present study.

Note that the implementation intentions in the present study were again not assigned by the experimenter but were individually chosen, albeit from a proposed list of options (for a similar procedure see Achtziger et al. 2008, Study 2). This is one aspect of the present research that distinguishes it clearly from earlier implementation intentions studies on the heightened accessibility of specified action cues (e.g., Aarts et al. 1999; Parks-Stamm et al. 2007; Webb and Sheeran 2006). This aspect is important as it enhances the ecological validity of the present findings. In everyday life, people are commonly not assigned action plans by some experts but do plan out their goal striving by themselves. This raises the question of whether in such cases processes underlying the beneficial effects of

planning out one's behavior by implementation intentions might also involve a heightened accessibility of the selected action cues. The present findings indicate that this might indeed be the case.

A further positive aspect of the present study rests in the fact that commitment to participants' implementation intentions was manipulated, and that implementation intention commitment was found to be a prerequisite for the postulated heightened activation of specified cues (i.e., the chosen options). Previous research has only focused on goal commitment as a potential moderator of implementation intention effects on goal attainment, and these studies (e.g., Sheeran et al. 2005) used a correlation approach where the strength of goal commitment was measured rather than manipulated. That strength of commitment to implementation intentions may also qualify as a strong moderator has been overlooked so far. However, the present study experimentally varied commitment to implementation intentions and observed that high implementation intention commitment is a prerequisite for heightened activation of the cues specified in the if-component. This finding suggests that high commitment to one's implementation intentions should also be a prerequisite for the beneficial effects of implementation intentions on goal attainment. Before accepting this conclusion, one might want to object that the manipulation of participants' commitment to their implementation intentions in the present study may have boosted their commitment to the super-ordinate goal intention; thus it was not increased implementation intention commitment but rather increased goal commitment that had produced the observed heightened accessibility effects. Yet a meta-analysis including 34 studies showed that the effects of forming implementation intentions on goal commitment (i.e., the subsequent strength of goal intention) are negligible (Webb and Sheeran 2008, Study 1). Therefore, we can confidently rule out the possibility that the manipulation of the implementation intention commitment in the present study did unfold its effects via the modification of the strength of the goal intention (i.e., weakening/strengthening commitment to the implementation intentions should not also have weakened/strengthened the super-ordinate goal intention).

Finally, the present study used a cancelling disengagement manipulation with respect to the super-ordinate goal, and this manipulation was found to undermine the otherwise observed better recall of chosen options in the high implementation intention commitment participants. So far, implementation intention research has only addressed the following features of the super-ordinate goal intention as potential moderators of implementation intention effects (Gollwitzer and Sheeran 2006): the strength of the super-ordinate goal intention (e.g., Sheeran et al. 2005, Study 1) and whether or not the situational context activates the super-ordinate goal (Cohen et al. 2008, Study 1; Sheeran et al. 2005, Study 2). The results of Study 2 suggest that for implementation intentions to unfold their effects it also needs to be assured that people have not given up on the super-ordinate goal (i.e., the goal has not been cancelled). This goal disengagement finding of the present Study 2 nicely lines up with findings in research on the ISE (intention superiority effect; Goschke and Kuhl 1993). For instance, Marsh et al. (1998) observed in a lexical decision task that was conducted after an intention was cancelled, that memory for this intention became inhibited relative to material that was not associated with the intention. Research on the ISE manipulated disengagement from an intention not only by cancelling it (as was done in the present Study 2) but also by allowing participants to fulfil it (Förster et al. 2005; Marsh et al. 1998). One wonders therefore whether using a fulfilment manipulation of disengagement in our Study 2 would have produced the same results as the chosen goal cancelling manipulation of disengagement.

General discussion and conclusion

Implementation intention theory maintains that after forming an if–then plan, a mental link is created between the specified cue and the goal-directed behavior (Gollwitzer 1993, 1999). This link is expected to result in a heightened cognitive activation of the specified cue leading to heightened cognitive accessibility of the if-part of the implementation intention. We tested whether the postulated heightened activation of selected action cues results in specific attention and long-term memory processes. This was done in two studies in which participants were asked to select the action cues on their own. In Study 1, attention processes associated with the specified cues were investigated by means of a dichotic listening task. In dichotic listening tasks it is assumed that since our attention is limited, it is difficult to spread attention to all information processing channels at once; one is only able to effectively attend to one channel at a time (e.g., Broadbent 1954; Bryden 1988). We presented words to the unattended channel that described individually specified cues. Simultaneously, participants repeated semantically unrelated words presented to the attended channel. Compared to control participants, implementation intention participants responded slower to the words presented to the attended channel if specified cues were presented to the unattended channel. This suggests that despite being strongly distracted, specified cues still attract attention; implicating that even when being strongly involved in other tasks, idiosyncratically specified cues selected for enacting goal-directed behavior will catch attention.

Study 2 tested whether the heightened activation of specified cues is also indicated by a better long-term memory of these cues compared to alternative cues. It was observed that both after 15 min and after 2 days, specified action cues were better remembered than alternative cues. These effects were moderated by the commitment to stick to one's action plans and by holding the super-ordinated goal. Participants with low commitment did neither show a memory advantage for the specified cues after 15 min nor after 2 days. Also, participants who no longer held the super-ordinate goal did not show a better memory for specified cues compared to non-chosen alternatives and this even though commitment to the implementation intentions had been induced to be high.

Manipulating the retention interval of action cues in the 2 days delay condition distinguishes Study 2 clearly from other research on the accessibility effects of forming implementation intentions. As these earlier studies tested the heightened cognitive accessibility of cues specified in the if-component of implementation intentions right after forming these plans or at most a couple of hours later. As we did not announce that participants in the 2-day condition would be asked which cues they had specified one can assume that they were not motivated to use external aids or memorization strategies to achieve the observed heightened recall performance for selected cues. Accordingly, we can assume that the observed strong memory advantage for specified action cues is primarily due to a state of heightened activation that persisted for 2 days after their formation.

In conclusion, research on action control by implementation intentions (summary by Gollwitzer and Sheeran 2006) has shown that making if–then plans is a good strategy for attaining one's goals as it helps to overcome the major problems of goal striving (e.g., getting started, staying on track, and not overextending oneself e.g., Bayer et al. 2010; Brandstätter et al. 2001). This strategy has been found to hold up its promise even when goal-striving is challenged by the lack of relevant skills, competitive opponents, habitual antagonistic responses, or a psychological disorder (e.g., Achtziger and Gollwitzer 2010; Gollwitzer et al. 2010).

Given this impressive track record, one wonders on which processes these beneficial effects of implementation intentions on goal attainment are based. The present studies analyzed a process pertaining to the cues specified in the if-component of implementation intentions: the heightened activation of the mental representations of these cues. As it turned out, such heightened activation was observed no matter whether it was assessed via the attraction of attention or by an increased recall performance. It was found to be stable over time, but dependent on a strong commitment to the implementation intentions formed and an ongoing concern for the super-ordinate goal.

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