

## Working Memory Capacity and Self-Regulatory Behavior: Toward an Individual Differences Perspective on Behavior Determination by Automatic Versus Controlled Processes

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In the present research, the authors investigated how individual differences in working memory capacity moderate the relative influence of automatic versus controlled precursors on self-regulatory behavior. In 2 studies, on sexual interest behavior (Study 1) and the consumption of tempting food (Study 2), automatic attitudes toward the temptation of interest had a stronger influence on behavior for individuals who scored low rather than high in working memory capacity. Analogous results emerged in Study 3 on anger expression in a provoking situation when a measure of the automatic personality trait of anger was employed. Conversely, controlled dispositions such as explicit attitudes (Study 1) and self-regulatory goals (Studies 2 and 3) were more effective in guiding behavior for participants who scored high rather than low in working memory capacity. Taken together, these results demonstrate the importance of working memory capacity for everyday self-regulation and suggest an individual differences perspective on dual-process or dual-system theories of human behavior.

*Keywords:* working memory capacity, self-regulation, self-control, dual-process theories, automatic and controlled processes

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In everyday life, some people often act more strongly on impulse than do others. For instance, some yield easily to the temptation of a tasty desert, even though they know that it will be bad for their weight. Some easily lose their tempers and act on aggressive impulses when provoked by another person, often neglecting the long-term consequences of this conduct. On the other hand, some people are remarkably good at fighting off tempting impulses in the service of long-term goals and standards, often admired by others as virtuous, self-controlled individuals. Why do people differ so much as to whether they appear to be the master of their impulses or—“vice” versa—more like their slaves?

The present article provides one answer from an individual differences perspective on dual-process theories of the mind, which have become prominent accounts of human behavior in many areas of psychology (Barrett, Tugade, & Engle, 2004; Carver, 2005; Chaiken & Trope, 1999; Evans, 2008). Dual-process models assume that there are two different modes of information processing, albeit different labels have been employed in order to denote this division, such as automatic versus controlled (Schiffrin

& Schneider, 1977), spontaneous versus deliberative (Fazio, 1990), experiential versus rational (Epstein, 1990), hot versus cool (Metcalf & Mischel, 1999), associative versus rule based (Slovman, 1996; Smith & DeCoster, 2000), or impulsive versus reflective (Strack & Deutsch, 2004). Some authors also have proposed that distinct cognitive systems underlie these processes (e.g., Lieberman, Gaunt, Gilbert, & Trope, 2002; Smith & DeCoster, 2000; Strack & Deutsch, 2004). Despite the differences in labels and scope, almost all authors have agreed on the general distinction between processes that are automatic, in the sense of fast, unintentional, and effortless, and those that are controlled, that is, slow, intentional, and effortful (Bargh, 1994; Evans, 2008). In this article, we refer to these two kinds of processes with the widespread terms *automatic processes* and *controlled processes*, respectively.

Even though the main thrust of dual-process or dual-system theories has been to explain how judgments or decisions are driven by automatic processes versus controlled processes, some theories have explicitly specified the manners in which both types of processes may influence actual behavior. According to the reflective impulsive model (Strack & Deutsch, 2004), for instance, behavior is the joint outcome of automatic and controlled processes instigated in the impulsive and reflective systems, respectively. The impulsive system generates quick and spontaneous behavioral tendencies through the process of spreading activation in an associative network. Specifically, the impulsive system contains associative clusters that have been created or strengthened by temporal or spatial co-activation of external stimuli or situational features, affective evaluations, and associated behavioral responses. For instance, through experience, a positive *automatic attitude* toward chocolate may be formed by linking the concept of chocolate and positive affect, and this automatic attitude may then influence consumption behavior in similar situations via the activation of behavioral schemas of approach (Chen & Bargh, 1999; Neumann, Hülsebeck, & Seibt, 2004; Strack & Deutsch, 2004; see Petty, Fazio, & Briñol, 2008, for an in-depth discussion of the automatic attitude concept). As a second example relevant to the present research, a person may repeatedly associate provocation by others and a behavioral tendency to return the provocation (see Mischel & Shoda, 1995) and, by linking this association with the self, develop an *automatic personality trait* to retaliate provocation that guides future behavior in similar situations (Asendorpf, Banse, & Mücke, 2002; Greenwald et al., 2002; Schnabel, Banse, & Asendorpf, 2006).

The reflective system, by contrast, is “responsible for generating explicit judgments and decisions and for executive functions such as overcoming habits or putting together action plans in new situations” (Strack, Werth, & Deutsch, 2006, p. 208). These functions are achieved through relatively slow controlled processes based on symbolic representations and operations (Smith & DeCoster, 2000). Hence, the reflective system provides a flexible correction tool permitting a fairly large degree of control over decisions and actions. However, the flexibility achieved by these higher order mental transformations comes at a cost: In accordance with most other dual-process or dual-system accounts (e.g., Evans, 2008; Fazio & Towels-Schwen, 1999), it is assumed that the cognitive capacity for controlled operations is limited (Strack & Deutsch, 2004).

From a theoretical perspective, conflicts may arise either within each system or between the two systems. For instance, a stranger’s offer of food may lead to the automatic activation of competing behavioral schemas of approach (due to the food) and avoidance (due to the stranger) in the impulsive system. Regarding conflicts within the reflective system, people may hold conflicting explicit values that need to be resolved by processes of reasoning or dissonance reduction before a clear behavioral intention can be formed (Strack & Deutsch, 2004). However, the prototypical self-control dilemma may best be characterized by a conflict between automatic (impulsive) determinants on the one hand and controlled (reflective) forces to restrain behavior on the other (Carver, 2005; Hofmann, Rauch, & Gawronski, 2007; Strack & Deutsch, 2004). For example, a person who is being offered a tasty desert may harbor positive automatic attitudes toward the tempting object but, at the same time, may be motivated to restrain his or her caloric input. Which of the two types of dispositions will eventually gain control over actual behavior? One answer along the lines of this article is that it will depend on whether a person has sufficient working memory capacity at his or her disposal in order to enable controlled processing to override automatic processing. More concretely, we will argue that *working memory capacity* (WMC), a construct that has received widespread attention in the cognitive literature (e.g., Engle, 2002; Kane, Bleckley, Conway, & Engle, 2001), reflects the type of capacity needed for controlled processes to outweigh automatic processes. In order to elucidate this point, we will first provide a brief overview of what is known about WMC from the cognitive literature and then relate WMC to dual-process theories of the mind and self-regulatory behavior.

## WMC

In their seminal article, Baddeley and Hitch (1974) proposed a tripartite model of working memory as composed of two slave storage systems (the phonological loop and the visuo-spatial sketch pad) and a coordinating master system, the *central executive*. Even though there is no generally agreed on definition of the central executive to date (e.g., Baddeley, 2003; Miyake & Shah, 1999), most researchers have regarded it as a mental faculty that has evolved in order to maintain information in a conscious, active state; to support thought processes by mental transformations; and to provide an interface between long-term memory and action. Arguably the most important among the various functions that enable the broad spectrum of central executive functioning (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000) is the ability by which we maintain information in working memory and shield it from interference or distraction (e.g., Barrett et al., 2004; Engle, 2002; Kane et al., 2001; Norman & Shallice, 1986). This ability has been referred to as WMC (or executive attention; e.g., Engle, 2002). Contrary to what its name may suggest, WMC is not so much about memory capacity in terms of storage volume per se but rather about

the ability to control attention to maintain information in an active, quickly retrievable state. Thus, WM capacity is just as important in the retention of a single representation, such as the representation of a goal [ . . . ], as it is in determining how many representations can be maintained. WM capacity is not directly about memory—it is about using attention to maintain or suppress information. (Engle, 2002, p. 20)

Individuals differ in this ability (Barrett et al., 2004), and these individual differences can be reliably assessed with complex span tasks (for a review, see Conway et al., 2005). In these tasks, participants typically have to memorize presented information while at the same time engaging in an interfering secondary processing task. Individual differences measured with complex span tasks have been shown to predict performance on a wide range of real-world higher order cognitive abilities (e.g., Daneman & Carpenter, 1980; Kiewra & Benton, 1988). Subsequent research has established that different WMC tasks assess a common factor reflecting a domain-general capability that is independent of any one processing task (e.g., Kane, Hambrick, Tuholski, Wilhelm, & Payne, 2004; Turner & Engle, 1989).

### WMC and Dual Processes in Self-Regulatory Behavior

In order to understand the implications of WMC on behavior determination, it is important to specify the manner in which individual differences in WMC may relate to the relative influences of automatic versus controlled processes on self-regulatory behavior. In a recent review article, Barrett and colleagues (2004) argued that WMC may directly relate to differences in the ability to shield controlled processes from automatic ones. The authors concluded from a wealth of cognitive research that high WMC individuals are more successful in enacting controlled, goal-directed processing in attention-demanding circumstances. Conversely, among those low in WMC, "controlled processing breaks down and less appropriate or undesired responses emerge" (Barrett et al., 2004, p. 556). For instance, when parsing the meaning of syntactically ambiguous sentences, individuals low in WMC respond more quickly and rigidly to complex tasks or situations without considering alternative responses (MacDonald, Just, & Carpenter, 1992).

Even though most research conducted on WMC has focused on cognitive task performance, these considerations may have direct implications for the expression of automatic versus controlled dispositions in everyday self-regulatory behavior. As Carver (2005) suggested recently, our understanding of self-regulatory outcomes may be greatly enhanced by adopting the conceptual framework offered by dual-process or dual-system theories (see also Metcalfe & Mischel, 1999). From this perspective, a typical self-regulatory conflict may be characterized, on the one hand, by the presence of environmental stimuli that predispose a person automatically toward a specific course of action via the activation of automatic evaluations and associated behavioral schemas (Strack & Deutsch, 2004). On the other hand, individuals may harbor explicit attitudes about an attitude object and self-regulatory goals about the proper course of action in a given situation. Whether and to what extent such controlled dispositions are successfully translated into behavior, however, may critically depend on WMC. Specifically, WMC may be needed to both inhibit prepotent responses triggered by automatic dispositions as well as to maintain controlled dispositions in an active state so that they can be used as a standard of reference for behavior monitoring and execution (e.g., Baumeister & Heatherton, 1996; Carver & Scheier, 1998).

Preliminary evidence for these assumptions may be derived from influential research programs in the cognitive load tradition (e.g., Gilbert & Hixon, 1991; Macrae, Bodenhausen, Schloersc-

heidt, & Milne, 1999; Ward & Mann, 2000) and on ego depletion (e.g., Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven, Collins, & Neinhans, 2002; Vohs & Heatherton, 2000), which have shown that situational reductions in capacity or control resources usually elicit less self-controlled behavioral outcomes (such as overeating, overdrinking, or stereotyping).

The present approach complements these previous lines of research in an important way: In the cognitive load and ego depletion literature, the influence of automatic dispositions (or impulses) on self-regulatory behavior is typically inferred from the observation of group differences in behavioral outcomes, yielding only indirect evidence for the notion that different processes may have determined a given behavior of interest. We suggest that a more direct approach should additionally specify and measure automatic and controlled dispositions as markers for dual processes. Specifically, individuals are expected to differ in their automatic and controlled dispositions, and these individual differences should not be treated as error variance but rather may be capitalized on in order to trace the processes at play. Showing, for instance, that individual differences in automatic dispositions predict behavior better for low rather than high WMC participants would yield more direct evidence for the assumption that automatic processes determine behavior to a stronger extent in low WMC individuals (as compared with high WMC individuals) than does the mere demonstration of a mean difference in self-regulatory behavior between these groups.<sup>1</sup>

How can automatic and controlled dispositions be properly assessed? We argue that the recently developed class of implicit measurement tools may offer a promising avenue to satisfy the need for reliable and valid measures of automatic, impulsive behavioral precursors in self-regulation research (Hofmann et al., 2007). Implicit measures such as the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) have seen tremendous development in recent years (e.g., Wittenbrink & Schwarz, 2007). Because such measures typically use reaction latencies to tap into aspects of automatic information processing such as automatic evaluation (see Petty et al., 2008, for an overview), they do not necessarily hinge on participants' abilities and willingness to report a given construct of interest. Implicit measures may therefore be ideally suited to capture automatic, impulsive precursors of human behavior (Greenwald & Banaji, 1995; Wittenbrink & Schwarz, 2007). Traditional verbal self-reports in contrast may be most appropriate for the assessment of people's conscious goal standards and explicit attitudes according to which behavior is monitored and regulated in the reflective system (Strack & Deutsch, 2004).

<sup>1</sup> Moreover, mean differences between WMC groups need not necessarily emerge for all self-regulatory behaviors because automatic versus controlled precursors may determine behavior across a comparable behavioral range in low versus high WMC individuals, respectively. Without an assessment of automatic and controlled precursors in such cases, the absence of a mean behavioral difference between low WMC individuals and high WMC individuals may lead to the false conclusion that the processes underlying behavior determination did not differ between groups.

## Research Hypotheses and Previous Findings

Based on the above considerations, we hypothesized that automatic dispositions such as automatic attitudes or automatic personality traits would express themselves more strongly in behavior for individuals low in WMC rather than that for individuals high in WMC. Conversely, we hypothesized that controlled dispositions such as explicitly endorsed attitudes or self-regulatory goals would guide self-regulatory behavior more effectively in individuals high rather than low in WMC.

In previous studies, we investigated the differential impact of automatic and controlled processing as a function of situationally manipulated control resources. We found that eating behavior was more strongly determined by previously measured automatic attitudes toward the food object of interest when participants were put under cognitive load, depleted by an emotion suppression task, or given a small dose of alcohol (Frieze, Hofmann, & Wänke, in press; Hofmann & Frieze, 2008; Hofmann et al., 2007). Conversely, eating behavior was more strongly determined by self-regulatory goals to diet or explicit attitudes toward the food object for participants in the control group. Even though these results corroborate the conditional nature of self-regulatory behavior determination, situational manipulations such as these offer only indirect support for WMC as a potential key moderator underlying the expression of automatic versus controlled dispositions on self-regulatory behavior. More direct evidence from the stereotyping domain was reported in a study by Payne (2005, Study 2). He employed a process dissociation approach to estimate automatic bias and cognitive control in the weapon identification task (Payne, 2001) and predicted trait inferences toward a black target person from these estimates. Payne (2005) found that automatic bias was more predictive with regard to the negativity of trait inferences for participants performing low on an antisaccade task, an attentional task that has been shown to be influenced by individual differences in WMC (Kane et al., 2001).

## The Present Research

In the present research, we aimed at extending these prior findings in several ways: First, by sampling a broad range of domains prototypical for the conflict between automatic and controlled influences on behavior, that is, sexual interest behavior (Study 1), candy consumption (Study 2), and anger expression after provocation (Study 3), we sought to provide generalizable evidence for the hypothesis that individuals low in WMC exhibit a stronger link between automatic dispositions and behavior. Second, we aimed at a reliable and valid assessment of individual differences in WMC with the help of a prototypical complex span task from the cognitive literature, a measure of computation span from the WMC task battery by Oberauer, Süß, Schulze, Wilhelm, and Wittmann (2000). Third, we assessed different types of automatic dispositions, that is, automatic attitudes (Studies 1 and 2) and the automatic personality trait of angeriness (Study 3), with the help of measurement tools developed in implicit social cognition research (Greenwald et al., 1998; Karpinski & Steinman, 2006), and we investigated whether these different types of automatic dispositions interact with WMC in the expected direction. Finally, we assessed different types of controlled dispositions such as explicit attitudes (Study 1) or self-regulatory goals to control the

behavior in question (Studies 2 and 3) in order to broadly investigate the hypothesis that high WMC individuals are better able to act in accordance with their controlled dispositions.

## Study 1: WMC and Sexual Interest Behavior

Human sexuality is a classic example of the driving force of spontaneously triggered impulses on behavior. Consider the case of risky sexual behavior, in which people sometimes fail to use condoms in the heat of the moment, even though such behavior implies potential negative long-term consequences such as unwanted pregnancy or the transmission of sexual diseases (e.g., Loewenstein, 1996). Less drastic instances of self-control in sexual behavior can be found in the everyday regulation of attention to sexual stimuli. Life is full of tempting cues that attract our interest and conjure fantasies of hedonic sexual fulfillment. Fighting off such tempting cues by diverting attention elsewhere may thus be regarded as an important early stage in the self-control of sexual behavior.

In Study 1, we brought male heterosexuals into a tempting situation by having them watch erotic slides of women for as long as they wanted before answering questions about the persons displayed.<sup>2</sup> By minimizing external restrictions, the viewing time of sexual stimuli was strongly dependent on the decision of the participant to move on. Drawing on the theoretical assumptions above, we hypothesized that automatic attitudes toward sexual stimuli would predict the viewing time of erotic slides better for low WMC participants as compared with high WMC participants. Conversely, we expected that consciously endorsed, explicit attitudes would predict viewing time better for high WMC participants rather than low WMC participants.

## Method

### Participants

Fifty male heterosexual students from different disciplines at the University of Würzburg, between 19 and 29 years of age ( $M = 23.12$  years;  $SD = 2.24$ ), participated in exchange for a bar of chocolate and a ticket in a lottery worth €15.00 (US\$23.55). One foreign participant was excluded because he reported not being able to understand the written instructions. Another participant was excluded from data analysis because of error rates above 25% in the critical combined blocks of the Single Category IAT (Karpinski & Steinman, 2006; see below). Hence, the final sample consisted of 48 participants.

### Materials

*Single Category IAT (SC-IAT).* We assessed participants' automatic attitudes toward erotic pictures of women with a variant of the IAT (Greenwald et al., 1998) that included only a single target category rather than two target categories (Karpinski & Steinman, 2006). The task was explained to participants as a categorization

<sup>2</sup> In order to eliminate sources of variance irrelevant to our hypotheses, only men were used in Study 1 because of known sex differences in sexual motivation and viewing time parameters (Baumeister, Catanese, & Vohs, 2001; Rupp, 2007).

task in which they were to react as quickly as possible to the stimuli presented according to the category label assignments at the top of the screen. In the first critical block, participants had to respond with a right-hand key to erotic pictures of women. In addition, participants had to respond with the same right-hand key to pleasant pictures or words and with a left-hand key to unpleasant pictures or words. Hence, erotic stimuli and pleasant attribute stimuli shared the same response key in the first block. In the second critical block, the key assignment for erotic pictures was reversed, such that participants now responded with the left-hand key to erotic pictures as well as to unpleasant pictures or words and responded with the right-hand key to pleasant pictures or words. Hence, erotic stimuli and unpleasant attribute stimuli shared the same response key in this block. The order of block assignment was kept constant for each participant as the primary goal of this research was to assess interindividual differences in our sample (for discussions, see Egloff & Schmukle, 2002; Gawronski, 2002).

As target stimuli, we used 10 erotic color pictures of young, attractive women validated in a pretest (Hofmann, Friese, & Gschwendner, in press). Stimuli were taken from public Web sites with sexual content. Each picture depicted a different naked or half-naked physically attractive woman roughly between ages 20 and 30 years in a stimulating posture. All pictures contained at least the head and the upper part of the body. The women's breasts were always uncovered. Primary sexual characteristics were either covered by erotic underwear or the woman's hand posture or were hidden by the woman's legs. Hair color of the head varied gradually from blonde to black. As attribute stimuli, we used 3 pleasant and 3 unpleasant pictures taken from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005) and two pleasant and two unpleasant words (e.g., *happiness*, *hatred*). Each of the two critical blocks consisted of 70 trials. An automatic attitude index was calculated according to the improved scoring algorithm (D4) proposed by Greenwald, Nosek, and Banaji (2003), which essentially reflects the mean reaction time difference between the two critical blocks. Higher values indicate faster reactions when erotic stimuli and pleasant attribute stimuli share the same response key than when erotic and unpleasant attribute stimuli share the same response key. In order to estimate the reliability of this index, we created four mutually exclusive subsets of trials and calculated IAT scores separately for each subset. Cronbach's alpha across these four scores was .82.

*Explicit attitude measure.* Three bipolar 7-point rating scales were used in order to assess participants' explicit attitudes toward erotic stimuli in general ("I find erotic stimuli generally . . ."). The poles to the three items were *positive* versus *negative*, *engaging* versus *repulsive*, and *aesthetic* versus *unaesthetic*. An explicit attitude index was calculated by averaging the three items ( $\alpha = .76$ ). Higher scores indicate a more positive explicit attitude toward erotic stimuli.

*WMC task.* A frequently used computation span task (Oberauer et al., 2000) was employed for the assessment of individual differences in WMC. Following Oberauer et al. (2000), a set of equations was presented sequentially in each trial of the task. Each equation remained on the screen for 3 s, followed by a 1-s interstimulus interval until the next equation was presented.<sup>3</sup> Equations consisted of one addition (e.g.,  $3 + 5 = 8$ ) or one subtraction (e.g.,  $11 - 7 = 5$ ). The result of each equation, which was always a one-digit number, had to be remembered and entered in the

correct order on the keyboard after a set of equations had been shown. As a secondary task, participants had to judge each equation as either true or false within the 3-s presentation interval by pressing the appropriate key on the keyboard. Thus, participants had to memorize the presented results, while at the same time engaging in a distracting secondary processing activity. Two practice trials and 14 test trials were presented. The set length for test trials ranged from four to eight consecutive equations presented in ascending order. An index of WMC was computed by summing up the number of correctly entered sequences of results. We calculated the Spearman-Brown corrected split-half reliability of this measure ( $r = .79$ ) from two subsets of trials matched in set length. The average rate of correct responses to the secondary processing task was 91%, indicating that participants were seriously engaged in the secondary task while memorizing the results.

*Relative viewing time measure.* Viewing time was used as an unobtrusive measure of sexual interest (Brown, Amoroso, & Ware, 1976; Gress, 2005; Harris, Rice, Quinsey, & Chaplin, 1996). Following previous research (e.g., Gress, 2005), participants watched a random series of five erotic and five art pictures and answered two questions about each picture. The erotic stimuli were comparable with pictures used in the SC-IAT but displayed different persons. Pictures of art were chosen such as to approximately match sexual stimuli in levels of detail and color. Following each erotic picture, participants had to answer two questions from a randomly assigned set (e.g., "How much would you like to talk to this woman?"; "How much would you like to have this woman as a romantic partner?"). Two analogous questions were asked for each art picture (e.g., "How much would you like to hang this painting up in your living room?"). Participants indicated their answer via mouse click on response scales ranging from 1 to 7 that were tailored to each question. In order to discourage potential response norms to react as quickly as possible to the stimuli presented, we explicitly instructed participants that "the task is not about speed. Feel free to take as much time as you need in order to feel confident when answering a couple of questions about each picture."

In order to control for general differences in viewing times, the relative time spent looking at the erotic pictures as compared with the (erotically irrelevant) art pictures served as our dependent variable of sexual interest. To this end, each participant's mean viewing time for art stimuli was subtracted from the mean viewing time for erotic stimuli, with higher scores indicating a relatively longer viewing time for erotic stimuli. In order to control for outliers, this index was computed across all picture trials that did not exceed the respective trial mean by more than three standard deviations (98.55% of trials).

### Procedure

The study was run in a laboratory close to the local main dining hall between 12:00 pm and 4:00 pm. Participants were recruited on campus with the help of flyers for "a short study concerning judgments about attractiveness and aesthetics." On arrival, up to 5

<sup>3</sup> Limitation of presentation time served to minimize strategic attempts for rehearsal, which are to be expected when presentation time is not limited (Engle, Cantor, & Carullo, 1992).

Table 1  
Means, Standard Deviations, and Overall Relationships Among Variables in Study 1

Variable	1	2	3	4
1. Relative viewing time (in s)	—			
2. Automatic attitudes	.24*	—		
3. Explicit attitudes	.25*	.31**	—	
4. WMC	-.07	.08	-.05	—
<i>M</i>	0.78	0.24	5.58	6.85
<i>SD</i>	2.83	0.43	0.85	3.14

Note. *N* = 48. WMC = working memory capacity.

\*  $p < .10$ . \*\*  $p < .05$ .

participants were greeted by a male experimenter and seated at separate cubicles, each equipped with a notebook. All parts of the study were instructed and run on the computer. Participants first performed the SC-IAT, followed by the WMC task and the viewing time measure. Explicit attitudes were assessed at the end of the study in order to avoid sensitizing participants too much to the erotic content of the stimuli. Finally, participants were thanked and debriefed.

## Results

### Preliminary Analyses

Table 1 presents the means, standard deviations, and correlations of the main constructs for the moderator analyses to follow. On average, participants spent somewhat more time looking at the erotic pictures as compared with the art pictures, a difference that was not significantly different from zero ( $M = 0.78$  s,  $SD = 2.83$ ),  $t(47) = 1.91$ ,  $p = .06$ . Across all participants, relative viewing time was marginally significantly related to automatic attitudes and explicit attitudes. Automatic and explicit attitudes were reliably correlated (see Table 1), but both constructs were clearly distinct from each other. WMC was not significantly correlated with viewing time, indicating that there were no mean differences between low and high WMC participants.

### Does WMC Moderate the Impact of Automatic Versus Controlled Dispositions?

In order to investigate whether WMC moderates the relative impact of automatic sexual attitudes on viewing time behavior, we performed a moderated regression analysis (Aiken & West, 1991) on relative viewing time as the dependent variable. As predictors, we entered automatic sexual attitudes, explicit sexual attitudes, and WMC as well as the cross-products between these predictors. In order to arrive at the correct standardized beta weights (Aiken & West, 1991), all variables were  $z$  standardized prior to computing the interaction terms.

The regression analysis ( $R^2 = .22$ ) yielded no main effect of automatic attitudes,  $\beta = .21$ ,  $t(41) = 1.16$ ,  $p = .25$ ; explicit attitudes,  $\beta = .19$ ,  $t(41) = 1.28$ ,  $p = .21$ ; or WMC,  $\beta = -.11$ ,  $t(41) = 0.76$ ,  $p = .45$ , on viewing time. However, as expected, a negative interaction between automatic sexual attitudes and WMC was obtained,  $\beta = -.37$ ,  $t(41) = 2.50$ ,  $p = .02$  (see Figure 1, left panel). A simple slope analysis (Aiken & West, 1991) showed that viewing time was strongly positively predicted by automatic attitudes in participants who scored one standard deviation below the mean of WMC,  $\beta = .58$ ,  $t(41) = 2.21$ ,  $p = .03$ ; and negatively but not significantly predicted in participants scoring one standard deviation above the WMC mean,  $\beta = -.16$ ,  $t(41) = 0.77$ ,  $p = .45$ .

Regarding explicit attitudes, a marginally significant moderator effect with WMC emerged,  $\beta = .29$ ,  $t(41) = 1.86$ ,  $p = .07$ . Importantly, simple slope analyses established that explicit attitudes were significantly related to viewing time in high WMC individuals,  $\beta = .48$ ,  $t(41) = 2.25$ ,  $p = .03$ ; but not in low WMC individuals,  $\beta = -.11$ ,  $t(41) = 0.51$ ,  $p = .62$  (see Figure 1, right panel). No other interaction was statistically significant.

## Discussion

In this study in the domain of sexual interest, heterosexual men's relative viewing time of erotic pictures was found to be significantly predicted by automatic but not explicit attitudes for those individuals low in WMC. In contrast, for those high in WMC, relative viewing time was significantly predicted by explicit but not automatic attitudes. This pattern of complementary

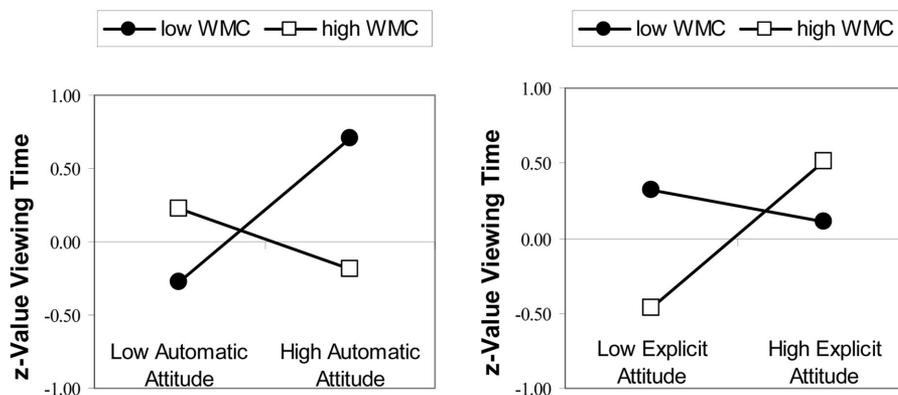


Figure 1. Moderator effects of working memory capacity on the influence of automatic sexual attitudes (left panel) and on the influence of explicit sexual attitudes (right panel) on the relative viewing time of erotic stimuli as compared with that of arts stimuli in Study 1.

effects suggests that self-regulatory behavior is not simply the result of additive effects of automatic and controlled processes. Rather, the result indicates a more complex interplay with WMC such that automatic attitudes translate more strongly into sexual interest behavior when WMC is low (rather than high), and explicit attitudes translate more strongly into sexual interest behavior when WMC is high (rather than low). These interactions were obtained regardless of the absence of a main effect of WMC on viewing time behavior. This pattern of findings offers support for WMC's status as a moderator variable of the relative influence of automatic processes versus controlled processes rather than as a direct predictor of sexual interest behavior.

A potential shortcoming of Study 1 is that only a distal indicator, sexual interest behavior, was employed. Clearly, in the domain of sexuality, a proximal indicator is difficult to realize in a laboratory setting (see Gailliot & Baumeister, 2006, for an ingenious solution that nevertheless depends on participants' retrospective self-reports). In the study to follow, we sought to provide additional evidence for our hypotheses in the domain of eating behavior by including a more direct behavioral measure, candy consumption.

Furthermore, we replaced our measure of explicit attitudes as an indicator for controlled processing by a measure of a self-regulatory goal to restrain behavior in the face of temptation. This decision was driven by the consideration that self-regulatory goals usually carry more direct behavioral implications (e.g., "I want to refrain from *eating* sweets") than explicit attitudes, which still need to be translated into a plan of action (Strack & Deutsch, 2004). In analogy to the notion of controlled processing goals from the cognitive literature on WMC (Barrett et al., 2004), self-regulatory goals to restrain one's behavior may constitute an even more appropriate operationalization of the restraint component in a typical self-control conflict, and therefore they constitute a more direct test of our hypothesis about the interplay between people's restraint goals and their available control resources as given by WMC.

## Study 2: Sweet Temptation

Eating behavior is a classic realm of self-regulation. As everyday experience tells, people often experience cravings toward alluring food such as chocolate. Why are these food cues so powerful in leading us into temptation? One potential answer is that environmental cues directly activate automatic evaluations in memory on encounter. These automatic evaluations may in turn activate behavioral schemas to consume the product of interest (Seibt, Häfner, & Deutsch, 2007; Strack & Deutsch, 2004). Moreover, automatically activated evaluations may even color how the sensual properties of the tempting stimulus are perceived. Importantly, whether and to what extent automatic associations guide consumption behavior and product perception may depend on certain boundary conditions such as individual differences in WMC.

In Study 2 we investigated whether automatic attitudes toward M&M's candy during a taste and rate test were more strongly associated with candy consumption and product liking for participants low in WMC than for those high in WMC. Furthermore, we hypothesized that the influence of the self-regulatory goal to refrain from eating sweets is moderated by individual differences in WMC in a complementary manner to what we expected for

automatic attitudes. More concretely, as the influence of automatic attitudes on behavior gets weaker with increasing WMC, the influence of the goal to refrain from sweets may increase because more capacity is available to represent this long-term goal and to shield it from inferences such as those stemming from automatic attitudes (Barrett et al., 2004).

## Method

### Participants

The sample consisted of 119 female undergraduate students from different disciplines at the University of Koblenz-Landau, between 18 and 44 years of age ( $M = 22.38$  years;  $SD = 0.32$ ), who participated in exchange for monetary compensation (€8.00 [US\$12.56]). One participant who complained about feeling sick during the experiment and 1 participant for whom the amount eaten could not be determined due to an experimenter error were excluded from analysis. Furthermore, participants were asked not to eat at least 1 hr before the study because the study would involve taste. All participants indicated that they had adhered to this prerequisite. For an unknown reason, 1 participant did not provide product liking ratings during the product test. Hence, the final sample consisted of  $N = 117$  participants for all variables except product liking ( $N = 116$ ).

### Materials

*SC-IAT.* The assessment of automatic attitudes toward candy stimuli followed a similar logic as the assessment of automatic attitudes toward sexual stimuli in Study 1. All procedural details were identical except for the modifications described in the following. As target stimuli, six different pictures of M&M's Peanuts were used. As attribute stimuli, we used three pleasant and three unpleasant pictures taken from the International Affective Picture System (Lang et al., 2005) and three pleasant and three unpleasant words (e.g., *happiness*, *disaster*). Each of the two critical blocks consisted of 75 trials. Cronbach's alpha across four subsets of IAT D4 scores was .79.

*WMC task.* We employed the same measure of WMC, computation span (Oberauer et al., 2000), as in Study 1, including only eight test trials for reasons of economy. The Spearman-Brown corrected split-half reliability of this measure, calculated from two subsets of trials matched in set length, was satisfactorily high ( $r = .85$ ). The average rate of correct responses to the secondary processing task was 0.90%.

*Candy test and rate.* In the product testing phase, a 125-g M&M's Peanut package was cut open and placed on a table napkin in front of each participant. Participants were asked to taste the product and rate it on a questionnaire handed to them. Participants were told that they had 5 minutes to complete their ratings, that they could do the tasting and rating simultaneously, and that they could have as many M&M's as they wanted (including a second package). After time had expired, the M&M's were taken out of the participants' reaches. Candy consumption was later determined by weighing the amount left with a precision balance and subtracting it from the preconsumption weight.

The questionnaire used for the product ratings contained a total of 22 questions related to the product (e.g., tastiness, liking,

Table 2  
Means, Standard Deviations, and Overall Relationships Among Variables in Study 2

Variable	1	2	3	4	5	6	7	8
1. Candy consumption (in grams)	—							
2. Liking during product test	.38**	—						
3. Automatic attitudes	.15*	.15*	—					
4. Goal to forego sweets	-.17*	-.33**	-.20**	—				
5. WMC	.12	.06	.14	-.03	—			
6. Positive affect	-.14	-.06	.11	.11	.03	—		
7. Negative affect	.10	-.04	.05	.04	-.03	.00	—	
8. Self-reported hunger	.07	.04	-.08	-.05	-.14	.09	-.07	—
<i>M</i>	28.49	4.08	0.32	3.11	3.64	2.32	1.88	3.11
<i>SD</i>	15.03	0.92	0.34	1.31	2.15	0.61	0.73	1.56

Note.  $N = 117$ . WMC = working memory capacity.

\*  $p < .10$ . \*\*  $p < .05$ .

thickness of the candy coating, strength of chocolate flavor), product look (e.g., color composition, package design), product pricing, and the product's suitability for various occasions (e.g., party, cinema, watching television at home). From these items, we sought to compute an index that reflected participants' evaluation of the product during the test and rate task. As the various questionnaire items were not suitable to form a homogenous scale ( $\alpha = .56$ ) and did not have a clear factor structure, however, we computed a homogeneous index of liking by averaging responses to the questions "How tasty is the product?" and "How much do you like the product?" ( $\alpha = .87$ ).

*Goal to forego sweets.* Embedded in a set of control questions at the end of the study, participants responded to the item "How important is it to you to forego enjoyable foods such as sweets?" on a scale ranging from 1 (*not at all*) to 6 (*very*). We reasoned that participants scoring high on this item harbor a stronger self-regulatory goal to abstain from consuming (too many) sweets than do participants scoring low on the item. The item was assessed at the end rather than at the beginning of the study in order to avoid sensitizing participants too directly with regard to food consumption prior to the test and rate task (for a discussion, see Hofmann et al., 2007).

*Control variables.* Because eating behavior may be influenced by differences in emotional states (Baucom & Aiken, 1981; for a review, see Herman & Polivy, 2004) and hunger feelings among participants, these variables were controlled for. In order to assess positive affect ( $\alpha = .82$ ) and negative affect ( $\alpha = .88$ ), we employed a German adaptation (Krohne, Egloff, Kohlmann, & Tausch, 1996) of the PANAS scales (Watson, Clark, & Tellegen, 1988) in a 5-point rating format. Self-reported hunger was assessed in retrospect with the item "How hungry did you feel right at the beginning of the product testing phase?" on a 6-point scale ranging from 1 (*not at all hungry*) to 6 (*very hungry*).

### Procedure

The study always took place between 2:00 pm and 5:00 pm. On arrival, participants were greeted by a female experimenter and seated in separate cubicles, each equipped with a computer. Participants were told that the study concerned "tastes and entertainment" and that it included some tasks on the computer, an entertainment part, and a product testing phase.

In the first part, participants performed the WMC task and the SC-IAT. In the entertainment part, participants engaged in two filler tasks, a quiz test and a short movie sequence that were unrelated to the present purposes and were intended to separate the assessment of automatic attitudes and our dependent measures. Participants then completed the mood measure and took part in the product testing phase in which they were asked to test and rate the candy. Finally, participants completed a set of control questions, were thanked, probed for suspicion, and debriefed.

## Results

### Preliminary Analyses

The descriptive statistics for the main and control variables and their intercorrelations can be seen in Table 2 for the whole sample. On the level of zero-order correlations, the SC-IAT was marginally predictive of eating behavior as well as of the reported liking during the product test. The goal to forego candies was negatively associated with candy consumption and product liking during the product test, and it was also somewhat negatively related to SC-IAT scores.<sup>4</sup> Furthermore, the dependent variables, candy consumption and liking, showed some positive overlap while at the same time being distinct (see Table 2). Finally, WMC was neither related to the dependent variables, the predictor variables, nor the control variables.

### Moderator Analyses

In order to investigate whether WMC moderates the relative impact of automatic candy attitudes and of the goal to forego sweets on eating behavior, we performed a moderated regression analysis (Aiken & West, 1991) on grams of candy consumption as the dependent variable. As predictors we entered automatic attitudes, goal to forego sweets, WMC, as well as the cross-products between predictors. Again, all variables were  $z$  standardized beforehand.

<sup>4</sup> This latter secondary finding suggests that strong self-regulatory goals to forego sweets may have a top-down, long-term effect on the strength of automatically activated evaluations in memory (e.g., Rudman, 2004).

The regression analysis ( $R^2 = .14$ ) yielded no main effect of automatic attitudes,  $\beta = .13$ ,  $t(108) = 1.44$ ,  $p = .15$ ; goal to forego sweets,  $\beta = -.14$ ,  $t(108) = 1.52$ ,  $p = .13$ ; or WMC,  $\beta = .09$ ,  $t(108) = 1.02$ ,  $p = .31$ , on candy consumption. However, as expected, there was a negative interaction between automatic attitudes and WMC,  $\beta = -.21$ ,  $t(108) = 2.04$ ,  $p = .04$ , indicating that the relative influence of automatic attitudes on eating was significantly larger in participants with low WMC rather than high WMC (see Figure 2, upper left panel). A simple slope analysis (Aiken & West, 1991) showed that candy consumption was significantly positively predicted by automatic attitudes in people scoring one standard deviation below the WMC mean,  $\beta = .34$ ,  $t(108) = 2.44$ ,  $p = .02$ , and slightly negatively but not significantly predicted in people scoring one standard deviation above the WMC mean,  $\beta = -.08$ ,  $t(108) = 0.58$ ,  $p = .56$ . Furthermore, the interaction between the goal to forego sweets and WMC was also significant,  $\beta = -.25$ ,  $t(108) = 2.48$ ,  $p = .02$ ; such that candy consumption was significantly negatively predicted by the goal to forego sweets for participants high in WMC,  $\beta = -.39$ ,  $t(108) = 3.01$ ,  $p = .01$ ; but not for individuals who were low in WMC,  $\beta = .11$ ,  $t(108) = 0.77$ ,  $p = .44$  (see Figure 2, upper right panel). No further interaction was statistically significant. Finally, including positive affect, negative affect, and self-reported hunger as covariates in the equation slightly increased the beta weight of the two focal interaction terms: for Automatic Attitudes  $\times$  WMC,  $\beta = -.24$ ,  $t(105) = 2.27$ ,  $p = .03$ ; and for Goal to Forego Sweets  $\times$

WMC,  $\beta = -.24$ ,  $t(105) = 2.31$ ,  $p = .02$ , strengthening the robustness of results.

We conducted a second regression analysis ( $R^2 = .19$ ) on participants' liking judgments during the product testing phase as the dependent variable. Regression weights indicated that WMC had a reliable moderator effect on the influence of automatic attitudes on liking,  $\beta = -.21$ ,  $t(108) = 2.01$ ,  $p = .04$ . Analogous to the product consumption data, product liking was only significantly predicted in low WMC individuals,  $\beta = .30$ ,  $t(108) = 2.21$ ,  $p = .03$ ; but not in high WMC individuals,  $\beta = -.11$ ,  $t(108) = 0.85$ ,  $p = .40$ . Even though liking correlated only moderately with candy consumption, the graphical pattern of the interaction effect for liking (see Figure 2, lower left panel) was remarkably similar to the respective interaction effect for candy consumption. Finally, product liking was significantly negatively influenced by the goal to forego sweets on average,  $\beta = -.32$ ,  $t(108) = 3.57$ ,  $p < .001$ ; but—unlike product consumption—was not moderated by WMC,  $\beta = .13$ ,  $t(108) = 1.34$ ,  $p = .18$ .

Discussion

When do automatic associations toward a tempting object such as chocolate have a direct influence on product consumption and liking? The results of Study 2 suggest that individual differences in WMC qualify an answer: For individuals low in WMC, automatic candy attitudes significantly influenced how much chocolate was

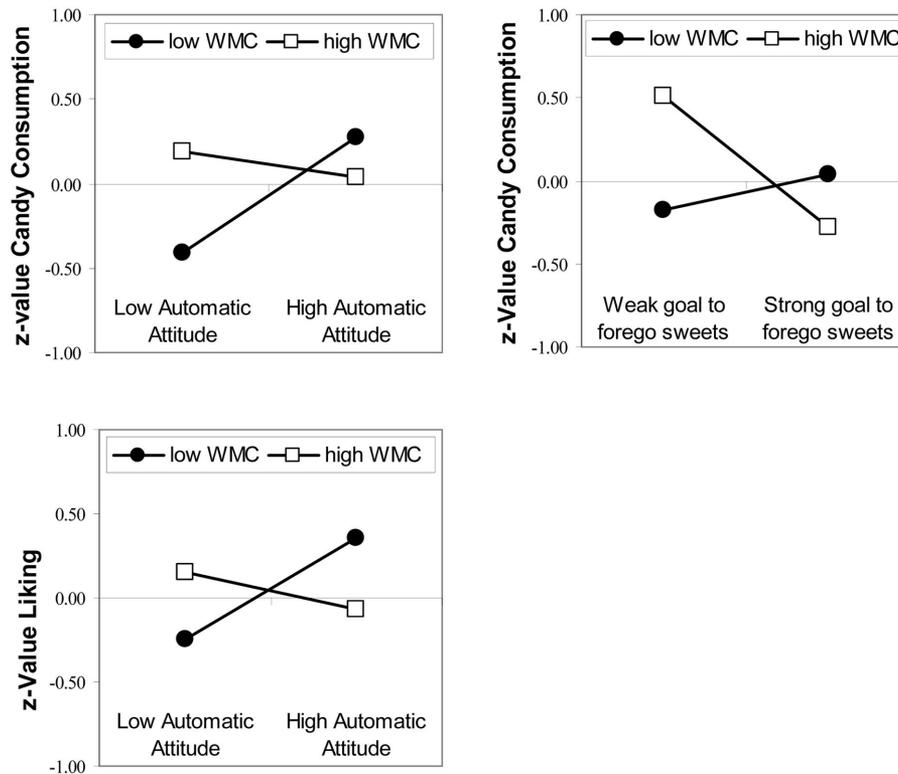


Figure 2. Upper part: Moderator effects of working memory capacity on the influence of automatic candy attitudes (left panel) and on the influence of the goal to forego sweets (right panel) on candy consumption in Study 2. Lower left panel: Moderator effect of working memory capacity on the influence of the automatic candy attitudes on self-reported liking during the product test and rate task.

consumed during the test and rate task and how positively the product was perceived during the product test. In contrast, automatic attitudes had only a negligible influence on eating and liking in individuals high in WMC. In a complementary manner, the self-regulatory goal to forego sweets effectively guided candy consumption only in individuals high in WMC, but not those low in WMC. These findings add further support to our hypothesis that low WMC leads to a more direct expression of automatic associations in thoughts and behavior, whereas high WMC may be necessary to inhibit the influence of automatically activated associations on behavior and to enable goal-directed action in accordance with self-regulatory goals.

Among participants low in WMC, automatically activated associations not only influenced product consumption but also their self-reported liking during the product testing phase. This finding suggests that automatic attitudes may constitute a potential source of information that can enter into an explicit judgment about a given target object (e.g., Gawronski & Bodenhausen, 2006). However, this seems to be the case only for individuals low in WMC but not for those high in WMC. A potential explanation for this difference in terms of validity assessment (e.g., Gawronski & Bodenhausen, 2006) is that those low in WMC may be more prone to draw on their gut feelings as a basis for a liking judgment whereas those high in WMC may be more likely to reject automatically activated affect as a valid basis for their judgment and to draw on additional sources of information instead.

### Study 3: Keeping Cool—WMC and Anger Expression

The social emotion of anger is like a double-edged sword: On the one hand, anger expression may be functional in showing to others that their conduct struck us as inappropriate and conflicted with our own aspirations. On the other hand, individuals have to engage in some kind of anger control or anger management in order to enable social harmony. Not surprisingly then, unbridled wrath is among the seven deadly sins of the Christian religious tradition. Nonetheless, anger is often experienced as a strong, emotionally laden impulse pressing for expression (Novaco, 1976). In order to inhibit or restrain its expression, self-control is necessary (Tice & Baumeister, 1993).

In Study 3, we applied our approach to the domain of anger, that is, to the role of dual processes on anger expression in a provoking social situation. Recently, researchers have begun to investigate the influence of automatic components in personality and have argued for the importance of automatic personality traits for social information processing (e.g., Asendorpf et al., 2002; Egloff & Schmukle, 2002; Greenwald et al., 2002; Greenwald & Farnham, 2000).<sup>5</sup> Even though the exact nature of automatic personality-congruent information processing has been a topic of considerable controversy (e.g., Rusting, 1998), empirical research applying reaction time measures of automatic personality traits has accumulated growing evidence for their predictive validity in a variety of domains such as anxiety (Egloff & Schmukle, 2002; Gschwendner, Hofmann, & Schmitt, in press) or shyness (Asendorpf et al., 2002), particularly with regard to behavior that is difficult to control.

In this study, we measured participants' automatic personality trait of anger with an IAT (Greenwald et al., 1998) assessing the association between the self and the concept of anger. As

a controlled counterpart, we assessed participants' self-reported goal standards to control anger. Our first hypothesis was that WMC moderates the influence of the automatic processes on behavior in a provoking situation such that individuals low in WMC should be particularly prone to react in accordance with their automatic personality trait of anger. Second, we expected that the influence of the goal to control one's anger is also moderated by WMC in a manner complementary to automatic processes. Specifically, we expected that low WMC individuals have more difficulty in living up to their goal standards of anger control than do high WMC individuals. As a final methodological consideration, we separated the assessment of predictors and criterion by a time lag of 2 weeks in order to investigate whether the expected interaction effects also hold when, other than in Studies 1 and 2, the behavior of interest is not part of the same experimental session.

## Method

### Participants

A total of 101 students (87 female, 14 male) from the University of Koblenz-Landau, between the ages of 19 and 35 years ( $M = 22.44$  years,  $SD = 3.93$ ), participated in a multiple session study either in exchange for course credit or €10.00 (US\$15.70). Students were recruited from 1st year psychology classes or from other departments. Three participants were excluded from data analysis because of error rates above 25% in the critical combined blocks of the anger IAT, leaving a remaining sample of  $N = 98$ .

### Procedure

The study consisted of two sessions. In Session 1, up to 5 participants at a time participated in separate cubicles. After participants had signed an informed consent for being filmed during parts of the experiment, they completed an Anger-IAT, an explicit self-report measure of anger control, and the WMC task. Two weeks later, participants took part one at a time in a variety of tasks, one of which, a social perception task, was relevant for the present study: Participants watched a short video sequence of themselves during their performance on the WMC task and subsequently received anger-provoking negative feedback, from an ostensible same-sex interaction partner, about their performance and about how likeable they appeared to be. Participants then saw a video sequence of the ostensible interaction partner performing the WMC task and were given the opportunity to retaliate against him or her by means of performance and sympathy feedback. These ratings served as indicators of anger expression after a provoking situation.

### Materials

**Anger-IAT.** We employed an Anger-IAT in order to assess the association between the self and words related to anger.

<sup>5</sup> Previous work has also used the term *implicit personality self-concept*. We prefer the more neutral term *automatic personality trait* here because the term *self-concept* may evoke too much of a conscious and elaborated sense of the self than is warranted from a theoretical and measurement perspective.

Five adjectives were used to denote an angry response (e.g., *angry, annoyed, indignant*) versus a calm response (e.g., *calm, relaxed, balanced*). Five target words represented self (e.g., *I, mine, myself*) versus other (e.g., *they, them, yours*). Each combined block of the IAT was composed of 20 practice and 60 test trials. All participants completed the self-angry block assignment first and the self-calm assignment second, as our primary interest was the assessment of individual differences (Gawronski, 2002). An index of the automatic personality trait of anger was computed according to the D4 measure proposed by Greenwald and colleagues (Greenwald et al., 2003), such that higher scores reflect a stronger association between anger and the self. The reliability of the IAT ( $\alpha = .82$ ) was computed from four subblocks of scores.

**Anger control.** The Anger Control Scale ( $\alpha = .82$ ) from the State-Trait Anger Expression Inventory (Schwenkmezger, Hodapp, & Spielberger, 1992; Spielberger, 1988) was employed in order to assess participants' self-reported tendencies to prevent their outward expressions of anger and to reduce their feelings of anger. Ratings were provided on a scale ranging from 1 (*not at all*) to 6 (*very much*). We assumed that persons scoring high on the Anger Control Scale harbor higher goal standards to control their anger than do those scoring low on the scale.

**WMC task.** We employed the same measure of WMC, computation span (Oberauer et al., 2000), as in Studies 1 and 2, involving 14 trials. The Spearman-Brown corrected split-half reliability of this measure was .83. Again, performance on the secondary task (judging equations) was high, as indicated by an average of 89% correct answers. While performing the task, participants were videotaped with the help of a computer-triggered Webcam situated on top of the screen such that the face of the participant during task performance was recorded.

**Anger induction and feedback measures.** A false-feedback paradigm was used in order to provoke participants with negative feedback about their performance and personality. Specifically, participants were instructed on the computer that one purpose of the study was

to investigate how other people can judge the quality of performance on difficult tasks by merely watching another person doing that task, i.e., without knowing about actual performance. For this purpose, you and a randomly assigned participant will see a short video-sequence of each others' behavior during the "equation task" from Session 1 and will be asked to judge each other on a variety of dimensions including concentration, conscientiousness, and a percentage estimate of correctly solved tasks. As such judgments may be influenced by the degree of liking for the person to be judged, a rating of liking will also be included.

In order to undergird the credibility of our cover story, each participant first saw a 10-s clip of his or her own performance during the WMC task. Then, participants were provided with the false feedback from the ostensible interaction partner on the following questions: (a) *According to you, how concentrated was the other person while working on the task?* (b) *According to you, how conscientious was the other person while working on the task?* (c) *How many (memory) tasks do you think the other person solved correctly?* (d) *How much do you like the other person?* and (e) *How much would you like to get to know the other person?* All five questions were answered on 6-point rating scales ranging from 1 to 6. The feedback of the other person was provided by showing each

rating scale graphically, with the response button "pressed" for the response that the other person ostensibly had chosen. When coded such that higher scores indicate a more negative feedback, the mean feedback rating provided to participants across the five items was 4.8. Thus, the feedback was clearly at the negative end of the scale but still not so negative as to be implausible.

After the anger induction, participants were told that they would now see the video sequence from the other person. The mock interaction partner was always chosen such as to match participant sex. For this purpose, we had prepared one male and one female confederate video of 10 s each. Based on pretesting, two confederates were chosen that both looked like students from the local university (which they in fact were not), and both were of average likeability. After having seen the video, participants judged the interaction partner on the same five questions as above in the expectation that this feedback would then be provided to him or her. Thus, participants had the opportunity to retaliate against the other person for the negative feedback received. A principal components factor analysis with promax rotation indicated two distinct factors, with items (a) to (c) loading very highly ( $>.80$ ) on one factor, performance feedback, and with items (d) and (e) loading very highly ( $>.90$ ) on a second factor, social feedback. Hence, two measures were computed such that higher scale scores indicated a more negative performance/social feedback, respectively. The performance feedback measure ( $\alpha = .85$ ) and the social feedback measure ( $\alpha = .87$ ) were correlated moderately ( $r = .45, p < .001$ ).

## Results

### Preliminary Analyses

The means, standard deviations, and correlations among the variables in Study 3 are presented in Table 3. In absolute terms, the average retaliated social feedback tended to be quite negative, supporting the effectiveness of our provocation manipulation. Even though a relative comparison between different types of feedback should be interpreted with caution, social feedback was more negative than performance feedback,  $t(100) = 6.41, p < .001$ , suggesting that social feedback was the primary outlet of the anger that had been provoked.

Table 3  
Means, Standard Deviations, and Overall Relationships Among Variables in Study 3

Variable	1	2	3	4	5
1. Automatic personality trait of angeriness	—				
2. Anger Control Scale	-.19*	—			
3. WMC	-.07	.03	—		
4. Performance feedback	.10	-.22**	-.09	—	
5. Social feedback	.19*	-.31**	-.23**	.45**	—
<i>M</i>	-0.39	4.01	6.00	3.45	4.12
<i>SD</i>	0.23	0.91	3.53	0.88	1.07

Note.  $N = 98$ . Higher performance scores and/or higher social feedback scores indicate a more negative feedback. WMC = working memory capacity.

\*  $p < .10$ . \*\*  $p < .05$ .

On the level of zero-order correlations, the Angriiness–IAT and the self-report measure of anger control were marginally significantly related such that a high automatic self-concept of anger was associated with less self-reported anger control. Moreover, automatic anger was marginally associated with more negative social feedback in response to the interaction partner's judgment. Anger control in turn was associated with less negative performance and social feedback. Furthermore, there was a negative association between WMC and social feedback, indicating that participants low in WMC provided more negative social feedback than did participants high in WMC.

### Moderator Analyses

In order to investigate whether and how WMC moderates the influence of the automatic personality trait of anger, as well as of goal standards of anger control, on the expression of anger in a provoking situation, we conducted two multiple moderated regression analyses on performance and social feedback as criteria, respectively. As predictors we entered the automatic personality trait of anger, anger control, WMC, and the interactions among these variables. Again, all variables were  $z$  standardized prior to computing the interaction terms (Aiken & West, 1991).

Concerning performance feedback, the regression analysis ( $R^2 = .08$ ) yielded only a marginally significant main effect of anger control in the context of the other predictors,  $\beta = -.20$ ,  $t(91) = -1.93$ ,  $p = .06$ . No other regression weight was significant, all other  $\beta$ s  $< .13$ . Regarding the regression on social feedback as the criterion ( $R^2 = .27$ ), however, the estimated average effect of the automatic personality trait of anger,  $\beta = .14$ ,  $t(91) = 1.51$ ,  $p = .14$ ; was significantly moderated by WMC,  $\beta = -.26$ ,  $t(91) = 2.93$ ,  $p = .004$ . The negative sign of this interaction indicates that, as expected, the relationship between the automatic anger trait and negative social feedback got weaker with increasing WMC. The nature of this interaction is depicted in Figure 3 (left panel). Simple slopes analyses confirmed a strong relationship for low ( $-1$  SD) values of WMC,  $\beta = .40$ ,  $t(91) = 3.06$ ,  $p = .003$ ; and a nonsignificantly negative relationship for high ( $+1$  SD) values of WMC,  $\beta = -.12$ ,  $t(91) = .99$ ,  $p = .33$ .

In a complementary manner, the average negative effect of anger control on social feedback,  $\beta = -.24$ ,  $t(91) = 2.53$ ,  $p = .01$ ;

was also significantly moderated by WMC,  $\beta = -.21$ ,  $t(91) = 2.10$ ,  $p = .04$ . As can be seen from Figure 3 (right panel), higher anger control led to markedly less negative social feedback in high WMC participants,  $\beta = -.45$ ,  $t(91) = 3.58$ ,  $p = .001$ ; but there was no such relationship in low WMC participants,  $\beta = -.02$ ,  $t(91) = .16$ ,  $p = .87$ . Confirming the correlational analysis above, a significant main effect of WMC on social feedback emerged,  $\beta = -.21$ ,  $t(91) = 2.33$ ,  $p = .02$ .

### Discussion

Study 3 extends our findings to the domain of personality influences on behavior. Specifically, we found that the automatic personality trait of anger predicted negative social feedback in a provoking situation substantially for individuals low in WMC but not for individuals high in WMC. Conversely, self-reported anger control exerted a buffering effect on social feedback only in high WMC individuals but not in low WMC individuals. These results are consistent with a dual-process view of personality processing, arguing that automatic and controlled precursors compete for behavior determination. In such a conception, WMC may function like a gatekeeper by inhibiting the influence of automatic precursors and simultaneously fostering the influence of self-regulatory goal standards, by maintaining these standards in an active, conscious state so that they can be successfully used for goal-directed self-regulation (e.g., Carver & Scheier, 1998).

The expected moderator effects were clear cut for the sympathy feedback but did not emerge for performance feedback. One explanation for this difference is that participants primarily used the sympathy "channel" as the proper dimension for their expression of anger because a sympathy judgment is unchallengeable. A task performance judgment on the other hand is much more easily verifiable as it can be compared with objective performance indicators. Therefore, participants may have perceived only the sympathy but not the performance rating as a relevant dimension for retaliation.

### General Discussion

In the present research, we investigated whether individual differences in WMC moderate the relative influence of automatic

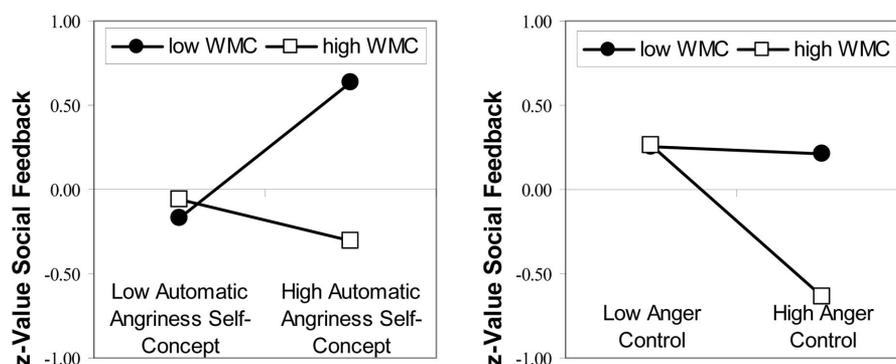


Figure 3. Moderator effects of working memory capacity on the influence of automatic anger (left panel) and on the influence of anger control (right panel) on social feedback given to a provoking interaction partner in Study 3.

versus controlled dispositions on self-regulatory behavior in the domains of sexuality, eating behavior, and anger expression. Across three domains, we consistently found that automatic dispositions such as automatic attitudes (Studies 1 and 2) or an automatic personality trait (Study 3) had a stronger influence on self-regulatory behavior for individuals low rather than high in WMC. More concretely, Study 1 showed that automatic sexual attitudes in heterosexual men predicted the relative viewing time of erotic material to a greater extent in participants who were low in WMC rather than high in WMC, as measured with a digit span task (Oberauer et al., 2000). In Study 2 we found that automatic attitudes toward M&M's candies in a subsequent test and rate task predicted online product liking and candy consumption better for low WMC individuals than for high WMC individuals. Finally, in Study 3 the automatic personality trait of anger predicted the degree of negative social feedback given to a provoking interaction partner more strongly in participants who were low rather than high in WMC. These findings suggest that automatic, impulsive processes of behavior determination (e.g., Strack & Deutsch, 2004) become more dominant in individuals who lack the capacity necessary to inhibit or override prepotent behavioral responses (Barrett et al., 2004; Engle, 2002).

Our findings also show that, as the influence of automatic dispositions on behavior wanes with increasing WMC, the influence of controlled dispositions increases in a complementary manner. Specifically, Study 1 showed that explicit attitudes guide sexual interest behavior more strongly for high WMC individuals; Studies 2 and 3 in turn indicated that self-regulatory goals, such as the goal to forego sweets or the goal to control one's anger, guide behavior more effectively in high WMC individuals.

To summarize, across diverse behaviors (viewing erotic pictures, eating sweets, retaliating a provocation), variants of automatic dispositions (automatic attitudes, automatic personality trait), and variants of controlled dispositions (explicit attitudes, self-regulatory goals), the present studies empirically demonstrate the importance of WMC as a key variable that shifts the relative weight of automatic processes versus controlled processes on everyday self-regulatory behavior. As we have argued in our theoretical introduction, the present moderator effects can be parsimoniously explained by WMC's double function to (a) inhibit prepotent automatic behavioral tendencies that may otherwise translate directly into behavior and (b) to retrieve, maintain, and shield explicitly endorsed attitudes and self-regulatory goals so that they can be continuously used for the self-monitoring of behavior.

As a potential methodological limitation to this approach, one may object that IAT measures may be contaminated by method-specific sources of variance related to central executive functioning (Mierke & Klauer, 2003). However, as indicated by the low and nonsignificant empirical correlations between IAT scores and WMC performance in all three studies, a potential contamination between predictor and moderator can be ruled out in the present investigations.

### *Implications for Self-Regulation Research*

We propose that the present approach expands our understanding of the self-regulation of social behavior by combining three basic elements of self-regulation research: automatic, impulsive

precursors of self-regulatory behavior (e.g., Marsh, Johnson, & Scott-Sheldon, 2001), self-regulatory goal standards (e.g., Carver & Scheier, 1998), and the role of individual difference variables on the outcome of self-regulatory conflicts (e.g., Barrett et al., 2004; Bogg & Roberts, 2004). Most centrally, by specifying and assessing automatic and controlled dispositions as predictors (rather than treating individual differences in automatic and controlled dispositions as error variance), the present measurement approach offers a flexible tool for tracing the nature of the processes that influence a given self-regulatory outcome variable. As our pattern of results makes clear, self-regulatory outcomes may often be the result of a complex interplay between automatic forces (such as automatic attitudes), controlled dispositions (such as self-regulatory goals), and key moderators (such as WMC). In addition, their joint consideration may enable a more precise prediction of self-regulatory outcomes than when each of these ingredients is studied in isolation (see Thush et al., 2008, for a recent application in the domain of addiction).

Over and above the possible benefits for conceptualizing self-regulatory conflicts, there are also some straightforward issues to pursue in future research. For instance, a recent study has shown that—contrary to traditional assumptions—WMC can be improved by repeated training, as reflected in a training-related increase in prefrontal and parietal cortex activity (Olesen, Westerber, & Klingberg, 2004). As a result, working memory training may provide beneficial effects for the self-regulation of behavior. We would predict that training effects may be at least partly due to an increased capacity to shield long-term goals from the interference of automatic dispositions, an explanation that could be empirically demonstrated by a weaker automatic attitude-behavior relation and a stronger self-regulatory goal-behavior relation in trained participants as compared with untrained participants.

A second avenue for future research is to relate the present work to the literature on automatic goal pursuit (e.g., Bargh, Gollwitzer, Lee-Chai, Barndollar, & Troetschel, 2001), implicit self-control (e.g., Fishbach & Shah, 2006), and implicit motivational processes (e.g., McClelland, Koestner, & Weinberger, 1989), which may all involve the operation of an implicit mode of working memory in goal pursuit (Hassin, 2005). These diverse areas of research have suggested the existence of nonconscious, automatized forms of self-regulation and have raised the question of how implicit working memory operations may interact with or complement the more conscious and effortful aspect of working memory, which has been the focus of traditional WMC research and of the present undertaking. For instance, can implicit working memory fully compensate for low (traditional) WMC because self-control is delegated to relatively effortless and unintentional behavioral routines?

### *Toward an Individual Differences Perspective on Dual-Process Models*

The present set of findings exemplifies the utility of combining the dual-process approach of social psychology with the individual differences approach from personality psychology in order to more fully understand the determinants of impulsive behavior (Carver, 2005). We believe that personality psychology is enriched by going beyond a mere description of the structure of impulsive personality to also specifying the processes by which automatically driven behavior versus controlled behavior is produced.

Directing the focus more strongly on (dual) processes will yield a more fundamental understanding of the psychological mechanisms underlying consistent patterns of behavior. For instance, conceptualizing impulsive personality as a system in which automatic processes have a chronically higher weight on behavior determination than do controlled processes may constitute an innovative new look for impulsivity research.

Dual-process or dual-system models in turn may profit from incorporating the notion of individual differences that determine the relative weight of automatic processes versus controlled processes on behavior determination. By using the present measurement approach, future research may attempt to fractionate the multifaceted functions of the central executive into different components (e.g., Miyake et al., 2000; Unsworth & Engle, 2007) and may investigate their specific contributions for the modulation of automatic versus controlled processes on behavior. Furthermore, a more complete picture may emerge as the present approach is extended to additional moderator candidates, such as individual differences in trait self-control (Tangney, Baumeister, & Boone, 2004), affective versus cognitive processing styles (Davidson, 2000), intuitive thinking styles (Epstein, Pacini, Denes-Raj, & Heier, 1996), behavioral activation versus behavioral inhibition (Carver & White, 1994), or fluid intelligence—which is conceptually and empirically related to WMC (Conway, Cowan, Bunting, Theriault, & Minkoff, 2002; Engle, Tuholski, Laughlin, & Conway, 1999).

#### *Predictive Validity of Implicit Measures*

From a measurement perspective, the present findings have important implications for the degree of incremental predictive validity that may be expected from implicit measures (Greenwald, Poehlman, Uhlmann, & Banaji, in press). By demonstrating the moderator role of individual differences in WMC, our findings add a more dynamic element to previous research applying the taxonomy of spontaneous behaviors versus deliberative behaviors (e.g., Asendorpf et al., 2002; Dovidio, Kawakami, & Gaertner, 2002). More specifically, our findings indicate that even one and the same kind of behavior can be better predicted by implicit measures in some participants (i.e., those low in WMC) than in others (i.e., those high in WMC). Had we just looked at the weak overall correlations between implicit measures and self-regulatory behavior in our samples, we would have falsely concluded either that the implicit measure was invalid or that automatic processes did not play a strong role in behavior determination. Taking individual differences in WMC into account, however, led to the substantial conclusion that the relationship between automatic dispositions and overt behavior is conditional (see also Cesario, Plaks, & Higgins, 2006; Perugini & Prestwich, 2007).

#### Conclusion

The present work contributes to our understanding of self-regulatory behavior by demonstrating that the influence of automatic and controlled processes on self-regulatory behavior differs systematically as a function of WMC. The current measurement approach (i.e., assessing individual differences in automatic predispositions, individual differences in controlled predispositions, and individual differences in the capacity to engage in controlled

processing) may help to gain a more realistic and complete picture of self-regulatory behavior determination than can approaches that focus on either the automatic nature of social behavior or the human potential for willpower and self-control. A more balanced approach may eventually improve our understanding and treatment of the far-reaching problems that arise from the competition between the automatic and controlled parts of human nature.

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