Journal of Personality and Social Psychology
2006, Vol. 91, No. 3, 385–405

0022-3514/06/$12.00 DOI: 10.1037/0022-3514.91.3.385

At the Boundaries of Automaticity: Negation as Reflective Operation

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The present research investigated whether automatic social–cognitive skills are based on the same representations and processes as their controlled counterparts. Using the cognitive task of negating valence, the authors demonstrate that enhanced practice in negating the valence of a stimulus can lead to changes in the underlying associative representation. However, procedural, rule-based components of negations were generally unaffected by practice (Experiments 1–3). Moreover, negations of evaluative stimuli did not influence automatic evaluative responses to these stimuli, unless the negation was included in the associative representation of a stimulus (Experiments 4–6). These results suggest that some practice-related skill improvements are limited to conditions in which a general procedure can be substituted by the retrieval of results of previous applications from associative memory. Implications for research on automaticity and social cognition are discussed.

Keywords: automaticity, practice, skill learning, evaluation, priming

Many facets of social cognition and behavior are influenced to a large degree by automatic processes (Bargh, 1997). Apparently, various affective and cognitive responses can occur with little awareness, intention, control, and cognitive effort if they are highly practiced (see E. R. Smith, 1989; E. R. Smith, Branscombe, & Borman, 1988; E. R. Smith & Lerner, 1986). Initially, research on automaticity in the social domain addressed rather simple processes such as stereotype or attitude activation (e.g., Devine, 1989; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Higgins, Rholes, & Jones, 1977). More recently, however, social psychologists have also studied automaticity in the domain of more complex phenomena, such as motivated behavior (Bargh & Barndollar, 1996); problem solving (Dijksterhuis, 2004); trait, causal, and goal inferences (e.g., Hassin, Aarts, & Ferguson, 2005; Hassin, Bargh, & Uleman, 2002; Uleman, 1999); or social comparisons (e.g., Stapel & Blanton, 2004).

The omnipresence of automatic phenomena in social psychology has led social cognition researchers to conclude that presumably "any skill, be it perceptual, motor, or cognitive, requires less and less conscious attention the more frequently and consistently it is engaged" (Bargh, 1997, p. 28) and thus may ultimately become automatic. A question that has received relatively little attention in the social–cognitive literature, however, is what happens to the underlying computations and representations when a complex social–cognitive skill becomes automatic. This is an important issue because some theories of automatization (e.g., Logan, 1988) suggest that rule-based, algorithmic processes may be substituted by one-step retrieval from associative memory (see Moors & De Houwer, 2006). In such cases, the outcome of a specific rule application is directly retrieved from memory, thus making a deliberate application of the rule obsolete. Such shifts possibly go hand in hand with changes in the processing capabilities of the skill. In many cases, however, association-based retrieval processes may be indistinguishable from controlled rule application. This may erroneously be interpreted as evidence that the controlled processes underlying the skill have themselves become automatic.

The present research focuses on representational and computational shifts for a particular mental operation: the negation of valence. Specifically, we demonstrate that the associative outcomes of repeatedly negated evaluations show typical features of automaticity, whereas rule-based components do not. Negations (i.e., the reversal of the truth value of a proposition) have been shown to play a crucial role in many social–cognitive phenomena, such as attitude change (e.g., Jung Grant, Malaviya, & Sternthal, 2004; Petty, Tormala, Briñol, & Jarvis, 2006), stereotype control (e.g., Kawakami, Dovidio, Moll, Hermsen, & Russin, 2000), and person perception (e.g., Mayo, Schul, & Burnstein, 2004). Thus, not only can the study of automaticity in the domain of negations be expected to improve our understanding of automatization processes per se, but it may also provide deeper insights into the underlying processes of many social–cognitive phenomena, including the ones mentioned above.

Automaticity and Unique Roles of Control

Traditionally, automaticity is defined by a set of features such as independence of awareness, independence of intention, high effi-

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This research was supported by Grant Str. 264/21-1 from the German Science Foundation. Portions of this article were presented at the Annual Meeting of the Person Memory Interest Group 2003, West Greenwich, Rhode Island. Experiments 4–6 were part of a doctoral thesis, submitted by Roland Deutsch to the University of Würzburg. We would like to thank the Würzburg Social Cognition Group, the Group for Attitudes and Persuasion at the Ohio State University, Barbara Kaup, and Eliot Smith for helpful suggestions on this research.

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ciency, and little opportunity to inhibit the automatic process voluntarily (see Bargh, 1994). There is great consensus that practice of a skill is a precondition for use of the skill to become more efficient and finally automatic (e.g., Gupta & Cohen, 2002; Logan, 1988; Moors & De Houwer, 2006). Many theories of automatization assume that shifts toward automaticity occur because practice makes time-consuming control processes obsolete. According to Schneider and Shiffrin (1977), a resource-limited process is responsible for coordinated response selection in nonautomatic responding. With consistent practice, however, the respective stimulus–response associations are permanently stored in long-term memory. As a result, merely perceiving a relevant stimulus immediately activates the response (Schneider & Chein, 2003). In a similar vein, Logan (1988) assumed that without practice, general but slow algorithms solve cognitive tasks. When this happens frequently for a specific task, the solution to that task becomes stored in memory and is quickly activated upon the perception of task-relevant stimuli. Consider, for example, the case of mental arithmetic. If a child learns to multiply one-digit numbers, he or she will start out with applying a general rule for multiplication (e.g., repeated additions). With extended practice of a task (e.g., mentally multiplying 6×6), the solution to this task (e.g., 36) becomes stored in memory and associated with the representation of the original task. Thus, the inefficient algorithm becomes obsolete, because the solution can be retrieved directly from memory (see also Zeelenberg, Wagenmakers, & Shiffrin, 2004).

What kind of processes may be responsible for inefficiency with unpracticed skills? Theories of control suggest that there may be a limited number of basic control functions, which are inherently inefficient. Among the most important functions are the assembly of new, unlearned sequences of behavior and planning (e.g., Bargh, 2004; Miller & Cohen, 2001); abstract, relational reasoning and the active maintenance of multiple representations (Hummel & Holyoak, 2003; O'Reilly, Braver, & Cohen, 1999); the regulation of response conflicts (e.g., Amodio et al., 2004; Botvinick, Braver, Barch, Carter, & Cohen, 2001); and the inhibition of goal-inappropriate habits (E. E. Smith & Jonides, 1999). There is evidence that these control functions are implemented in a limited number of interconnected neural systems (e.g., Heyder, Suchan, & Daum, 2004; Ridderinkhof, van den Wildenberg, Segalowitz, & Carter, 2004), the most important being the prefrontal cortex (Miller & Cohen, 2001; E. E. Smith & Jonides, 1999). Presumably, these control functions are strongly capacity limited and profit only little from practice. Thus, to the degree a skill contains such elements, it seems plausible that memory retrieval processes rather than automatization of the control functions themselves are responsible for performance enhancements.

In addition to memory-based automaticity, some researchers have proposed that abstract procedures or rules can become more efficient with practice (J. R. Anderson, 1993; Gupta & Cohen, 2002). Take again the case of mental arithmetic. Extended practice of multiplying one-digit numbers may also make the general rule or algorithm of repeated additions more efficient. In this case, the algorithm may remain the same, but it may become more efficient because of enhanced accessibility or attunement of the sequence of subprocesses (J. R. Anderson, 1993). Both rule strengthening and instance learning have been well documented in the literature (J. R. Anderson, Fincham, & Douglass, 1997; Gupta & Cohen, 2002; Logan, 1988; Schneider & Chein, 2003; Schneider & Shiffrin, 1977; Shiffrin & Dumais, 1981; Strayer & Kramer, 1990). However, it is less clear whether rule strengthening generates true automaticity. Rule strengthening was primarily documented with skills operating far from automatic performance. For instance, J. R. Anderson et al. (1997) had participants extensively practice different semantic rules over 4–5 days; response latencies were well above 1,000 ms in all experiments at the end of training. E. R. Smith et al. (1988) found evidence for an increase in the efficiency of a general procedure to infer traits from behaviors. However, the degree of training was rather limited (60–250 trials), and response latencies remained above 1,000 ms after training. Other studies reported comparable (or even lower) degrees of practice and speed of responding (Rüter & Mussweiler, 2004; E. R. Smith & Lerner, 1986). Thus, even though practice may indeed speed up the original computations, we are not aware of studies showing that extended practice results in very fast response latencies that would suggest independence from intentional control.

Automatic Social Cognition

The above analysis is of great importance for automaticity in the social domain. Phenomena such as stereotype and attitude activation can be readily reconstructed as instance-based automaticity. For example, perceiving a person of a stereotyped group or an attitude object may be sufficient to activate well-practiced stereotypic or evaluative associations in memory. The application of stereotypes, however, may require controlled processing to establish a relation between the stereotype and a concrete person. Even more so, complex social–cognitive skills probably represent a mixture of automatic activation in associative memory on the one hand, and core control processes on the other hand. For instance, pursuing an unpracticed goal involves the activation of the goal construct in memory, the directed search of possible means to achieve that goal, and their combination to new sequences of action (e.g., Bargh, 2004). To the degree that these genuine control elements cannot be fully automatized, one can expect that the computations underlying complex social–cognitive skills change during automatization. This assumption is in line with current dual-system models of social cognition (e.g., Lieberman, Gaunt, Gilbert, & Trope, 2002; E. R. Smith & DeCoster, 2000; Strack & Deutsch, 2004). These theories distinguish between two processing systems, which differ in the way and degree to which they support automatic processing. In these theories, the system responsible for cognitive control is assumed to generate and manipulate symbolic, propositional representations on the basis of abstract rules of reasoning. The automatic system, in contrast, is assumed to generate responses on the basis of simple associative structures and spread of activation through associated contents. These associative processes lack abstract thinking capabilities like negation or explicit representations of time, are content-specific, and are less flexible than reflection. Resembling Logan's (1988) instance theory, these models explicitly assume that frequently generating a response in a rule-based, controlled manner creates "the conditions for associative learning, so eventually the same answer can be retrieved by pattern-completion from the associative system, rendering the step-by-step procedure superfluous" (E. R. Smith & DeCoster, 2000, pp. 115–116). Hence, in these models, automatization is a consequence of responding being transferred from the rule-based, reflective system to the association-based impulsive system (Lieberman et al., 2002; Strack & Deutsch, 2004).

So far, very few studies have addressed the question of possible changes in the representations and computations underlying complex social cognitive skills (e.g., Rüter & Mussweiler, 2004; E. R. Smith, 1989; E. R. Smith et al., 1988; E. R. Smith & Lerner, 1986). From a general perspective, these studies provide evidence for both rule strengthening and instance learning. Yet, as described above, performance in these studies was far from automatic. Another ambiguity results from the fact that studies in the social domain usually estimate the degree of content-independent practice through the generalization of practice to new instances. However, observed generalization may have occurred because of memory activation instead of rule strengthening. For instance, E. R. Smith and Lerner (1986) repeatedly asked participants to indicate whether a given list of four traits was typical for a waitress (or a librarian). After participants practiced this task with typical and nontypical traits, the target stereotype was switched. Then, participants had to perform the same task with the librarian (or waitress) stereotype. E. R. Smith and Lerner observed a considerable transfer from one task to the other. As E. R. Smith and Lerner concluded, this may be regarded as evidence for a genuine speed up of the cognitive procedure independent of the content. However, one could object that the employed traits and stereotypes share semantic overlap. For instance, some traits that are stereotypically attributed to waitresses (e.g., being extraverted) are the exact opposite of what is stereotypically attributed to librarians (e.g., being introverted). Because activating one pole of a dimension in memory often increases the accessibility of the whole dimension (Park, Yoon, Kim, & Wyer, 2001), practicing to respond to the waitress stereotype may also enhance the accessibility of semantic contents relevant to the librarian stereotype, thus leading to transfer effects. Similar content-based effects may have also been prevalent in other studies using generalization of practice as a criterion (e.g., E. R. Smith, 1989; E. R. Smith et al., 1988). Generally speaking, as long as there is semantic overlap between the materials used for practice and transfer, results of generalization paradigms are still open to alternative interpretations.

In a similar vein, demonstrating that a preexisting complex social–cognitive skill can be executed with little intention, consciousness, control, and cognitive effort does not provide clear evidence that the skill is still based on the same computations as the controlled counterpart. Such demonstrations require experimental situations in which instance-based responding and rule-based responding yield diverging results. Relying on already existing skills makes this endeavor difficult, because it is not known what exactly is stored in memory by the virtue of previous practice.

The Present Research

The above analysis implies that the representations and computations underlying cognitive skills may change over the course of automatization. Changes in underlying representations are of greatest relevance for those social–cognitive skills, which originally include primary control functions, such as planning, regulation of unwanted habits, and abstract reasoning. In these cases, a shift from rule-based to association-based processing will go hand in hand with a loss of distinct properties of the original skill. Many previous studies demonstrating practice-related generalization effects in the social domain contain a semantic overlap in the employed stimulus material (e.g., E. R. Smith, 1989; E. R. Smith et al., 1988; E. R. Smith & Lerner, 1986). As such, these studies are limited in their conclusiveness of the observed generalization to new exemplars. In the present research, we tried to overcome these limitations by using a task that allows measurement of the unique impact of rule-based and content-based elements independent of generalization. Specifically, we designed an evaluation task comprising affirmations and negations attached to positive and negative words. This skill to negate the evaluative meaning of a proposition is particularly fit to overcome the problems associated with previous practice studies based on generalization. More precisely, we argue that comparing responses to affirmed and negated words allows for direct estimation of the speed of the procedure to negate.

A second reason for the study of negations is their significance for many social–cognitive phenomena. Negations have gained considerable interest in social–cognition research during the past decade. Generally, negations were shown to put a particular strain on cognition. With little motivation and resources, people were demonstrated to fail to extract the meaning of negations and to respond in a way opposite to what was implied by logic. For instance, in research on persuasion, several studies have demonstrated that persuasive attempts containing negated terms (e.g., *Drinking is not sexy*) can lead to attitude changes in the opposite direction of what was intended (e.g., making drinking more attractive; Christie et al., 2001; Jung Grant et al., 2004; Skurnik, Yoon, Park, & Schwarz, 2005). In the realm of behavior-to-trait inferences, Mayo et al. (2004) showed that perceivers need more cognitive resources to infer the absence of traits from behaviors than to infer their presence, unless there is a schema for transforming the negation into an affirmative concept (see also Hasson, Simmons, & Todorov, 2005). Studying the role of negations in stereotype control, Kawakami et al. (2000) found that highly extensive training in the negation of stereotypic associations can reduce their automatic activation in memory. In addition to these findings, numerous studies have suggested that attitudes and beliefs tend to sustain in memory at a residual level, even when their original basis was invalidated by negation (e.g., C. A. Anderson, 1982; Petty et al., 2006; Walster, Berscheid, Abrahams, & Aronson, 1967; Wyer & Unverzagt, 1985). A similar perseverance is involved in the innuendo effect, in which a negated negative statement about a specific person (e.g., *This politician was not bribed*) leads to more negative attitudes toward this person (Wegner, Wenzlaff, Kerker, & Beattie, 1981). Given the significance of negations for these phenomena, we expect the present research to provide deeper insights into the cognitive processes that may be responsible for the abovementioned findings.

Finally, negation can be seen as a prototype of an abstract, rule-based reasoning process. Particularly, explicit negations require a propositional representation, in which the meaning of the negated construct (e.g., *This is not a friend*) is activated and maintained in working memory while the meaning of the negated proposition (e.g., *This is an enemy*) is construed (e.g., Kaup, Zwaan, & Lüdtke, in press). Such maintenance and construal processes are a core function of cognitive control (Miller & Cohen, 2001) and may play an important role for a number of social–cognitive processes. For instance, generating explicit inferences about relations between people presumably requires symbolic, abstract reasoning (Hummel & Holyoak, 2003). Likewise, generating and correcting causal attributions may specifically rely on the same type of reasoning (e.g., Lieberman et al., 2002; Satpute et al., 2005). In their dual-system model, E. R. Smith and DeCoster (2000) described a number of social–cognitive processes that may be based on symbolic, rule-based processing, among them counterfactual thinking, social transmittal of knowledge, the justification of attitudes and behaviors, and the correction of socially undesirable stereotypes or attitudes (see also Strack & Deutsch, 2004). In a similar vein, Miller and Cohen (2001) argued that cognitive control involves the "active maintenance of patterns of activity that represent goals and the means to achieve them" (p. 171). Particularly, control is seen as responsible to store and flexibly switch between abstract rules of responding. Such processes are especially important for the negation of valence. Usually, words appear in affirmed versions, and their perception is often sufficient to activate their valence in memory. If a negation is attached to a word, a correct task solution requires one to override expressing the automatically activated evaluation, and to substitute it with the inferred valence. Thus, findings regarding the automatization of negations may help to determine how explicit social–cognitive processes involving flexible rule-based, propositional reasoning respond to enhanced practice.

To investigate the quality of automatization processes in the context of valence negation, we conducted a total of six experiments. In Experiments 1–3, participants practiced evaluating affirmed and negated positive and negative words. We expected that training would speed up responses in general through content-based mechanisms. However, the overall speed to negate the valence of a word should be unaffected by practice. In Experiments 4–6, we studied automatic evaluations of affirmed and negated positive and negative words in a sequential priming task. We expected that the stored evaluative meaning of a given word is activated automatically. However, negating its evaluative meaning should require higher order rule-based processes, unless the compound meaning of the negated word is stored as a separate instance in associative memory.

Experiment 1

The aim of Experiment 1 was to study how practice affects associative and rule-based aspects of evaluation. To disentangle these elements, we used the subtraction method proposed by Donders (1969). Specifically, we construed a task in which participants had to evaluate affirmed (e.g., *a party*) and negated (e.g., *no party*) versions of positive and negative words by pressing appropriate keys. Over six blocks, participants practiced this task in a total of 600 trials. In each of these blocks, a given word appeared equally often in an affirmed and a negated version. The rationale for using this setup becomes apparent in Figure 1. In response to both affirmed and negated target words, participants must determine the valence of the word to identify the correct key. As long as the words have a clear positive or negative connotation, this process is presumably based on memory activation. With affirmed targets (see Figure 1A), this memory activation process is sufficient to determine the correct response. With negated targets (see Figure 1B), however, the retrieved valence must be reversed to determine the correct response (see Clark & Chase, 1974; Gilbert, 1991; Gough, 1965; Wason, 1959). Hence, the difference in response latencies toward affirmed and negated targets can be used as an estimate of the time needed to reverse the word valence (Donders, 1969). Based on the considerations outlined above, we expected that the activation of word valence and the reversal of word valence are differentially affected by practice. Particularly, we expected that when participants retrieve the valence of a given word over and over again, its valence should become highly accessible in memory (Fazio, 1995). Moreover, the mapping of valence and response keys should be stored in memory, such that pressing the correct key associated with a given valence should become more efficient with practice. Therefore, we expected an overall speed up of response latencies. The reversal of the word valence, on the other hand, constitutes a general procedure that has its roots in higher order rule-based processes. As such, the speed of valence reversal should be unaffected by extended practice. In other words, the difference in response latencies for affirmed and negated words can be interpreted as a proxy for the speed of reversal, and this difference should remain constant over various levels of practice.

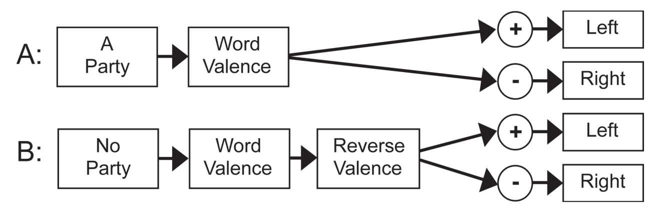

Figure 1. Response-latency model for Experiments 1–3. In response to affirmed (A) and negated (B) targets, the word valence must be determined in order to determine the correct response (left vs. right key). Negated targets, however, additionally require participants to reverse the word valence.

Method

Participants and Design

A total of 42 students of the University of Würzburg (28 women, 14 men) took part in a study purportedly concerned with attention and performance. Participants received €6 (approximately U.S. $5 at that time) as compensation. The experiment consisted of a 2 (word valence: positive vs. negative) × 2 (qualifier: affirmation vs. negation) × 6 (practice block: 1–6) within-subject design.

Procedure

The experiment was part of a larger set of unrelated studies and took about 40 min. The whole battery of studies took about 1 hr. Under the guise of studying the ability to concentrate while working with a computer, participants repeatedly evaluated affirmed and negated words. Participants worked on six blocks of practice, each consisting of 100 trials. The six blocks were separated by breaks of 20 s. In the course of each block, each of 20 stimuli (5 each affirmed positive, negated positive, affirmed negative, and negated negative) was presented 5 times. Consequently, participants evaluated each qualifier–word combination 30 times during this experiment. Each trial started with the presentation of a warning signal (XXX) in the center of the screen for 500 ms followed by a blank screen for 200 ms. Then the stimulus was presented in bold 30-point Arial font letters in bright yellow color on a black background. Participants were asked to press a left-hand key (*A* key) for positive stimuli and a right-hand key (*5* number pad key) for negative stimuli. After correct responses, the next trial started immediately, resulting in a response–stimulus interval of 700 ms. For incorrect responses, participants received error feedback (*Error! Positive – left, negative – right),* which remained on the screen for 1,500 ms. If participants did not respond within 2,000 ms, the trial was aborted, and a warning message (*Try to respond faster!*) was displayed for 1,500 ms. Immediately after feedback for errors and slow responses, the next trial started, resulting in a feedback–stimulus interval of 700 ms.

Materials

Each participant practiced with 5 positive and 5 negative words, each of which repeatedly appeared in both an affirmed and negated form. We conducted a pretest to identify negations of low frequency in everyday language. We reasoned that the use of frequently negated words would prevent participants from actually practicing negations because their valence could be directly retrieved from memory (see Experiment 6). For this purpose, negations of 53 positive and 53 negative words were judged by 71 psychology students with regard to their frequency and their valence. From these stimuli, we selected 10 positive and 10 negative words, which revealed low frequency estimates in their negated form, but still exhibited unambiguous valence (see Appendix A for the words and Appendix B for pretest data). Four random subsets, each consisting of 5 positive and 5 negative words, were chosen and combined with either an affirming or negating qualifier. Each participant was randomly assigned to one of the four subsets.

Results

Trials on which participants classified the target incorrectly (7.7%), as well as the first reaction in each block were excluded from analyses. No anticipations (reaction time [RT] < 300 ms) occurred. RTs decreased as a negatively accelerated function of practice, reaching an asymptote of learning after Block 4 (see Figure 2). This conclusion is supported by the results of a 2 (word valence) $\times$ 2 (qualifier) $\times$ 6 (practice block) analysis of variance (ANOVA) for repeated measures,[1] which yielded a main effect of practice block, $F(5, 205) = 44.16$, $p < .001$, $\eta^2 = .51$. The respective contrasts were significant up to Block 4 (all Fs > 6.80, all ps $< .05$), whereas no significant increase occurred in the last two blocks (all Fs < 0.50, all ps $\geq .5$). Most important to our hypotheses, participants responded slower to negated targets (M = 952 ms, SD = 119 ms) as compared with affirmed targets (M = 849 ms, SD = 104 ms), and this processing advantage of affirmed words was unaffected by practice. This conclusion is supported by a significant main effect of qualifier, $F(1, 41) = 358.60$, $p < .001$, $\eta^2 = .90$, and a nonsignificant interaction of Block $\times$ Qualifier, $F(5, 205) = 0.14$, $p = .96$, $\eta^2 < .01$ (see Table 1). To further specify this result, we calculated the cost of reversing word valence by subtracting the latencies of affirmed trials from the latencies of negated trials as a function of the six blocks. Independent of the degree of practice, responding to a negated word took about 100 ms longer than responding to an affirmed word.

In addition to these predicted effects, the specific valence of a word influenced response times in several ways. First, negative words (M = 940 ms, SD = 123 ms) were evaluated more slowly than positive words (M = 860 ms, SD = 102 ms), $F(1, 41) = 121.87$, $p < .001$, $\eta^2 = .75$. In addition, responses to negative words profited more strongly from practice than positive words, $F(5, 205) = 5.88$, $p < .001$, $\eta^2 = .13$. Finally, although affirmed words were always evaluated faster than negated words, this effect was somewhat smaller for negative words ($M_{affirmed}$ = 906 ms, $SD_{affirmed}$ = 124 ms vs. $M_{negated}$ = 975 ms, $SD_{negated}$ = 126 ms) as compared with positive words ($M_{affirmed}$ = 792 ms, $SD_{affirmed}$ = 91 ms vs. $M_{negated}$ = 929 ms, $SD_{negated}$ = 116 ms), $F(1, 41) = 75.42$, $p < .001$, $\eta^2 = .65$.

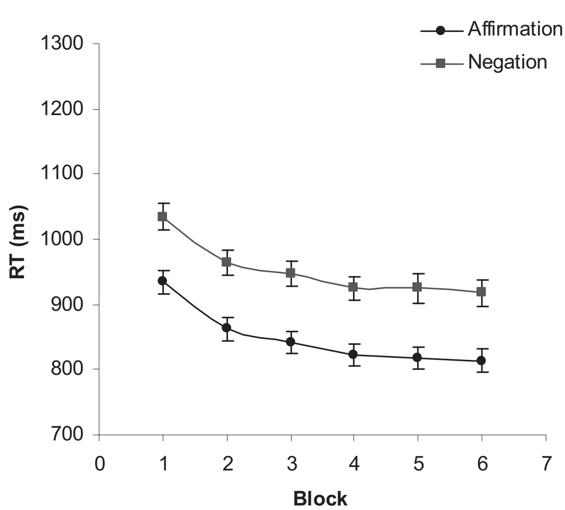

Figure 2. Response latencies to affirmed and negated words as a function of practice block (Experiment 1). Error bars indicate the standard errors of the means. RT = response time.

Discussion

The present results suggest that participants' performance in the evaluation task strongly profited from the training. In Block 6, participants needed 13% less time than in Block 1 to respond to affirmed words and 11% less time for negated words. Thus, our training procedure was indeed effective in speeding up responses in the evaluation task. In addition, contrast analyses indicate that latencies did not further decrease between Blocks 4 and 6, suggesting an asymptotic change in performance. Most important, however, the time required to negate the valence of a word was generally unaffected by practice. Overall, responses to negated words required about 100 ms more than responses to affirmed versions of the same words, and this difference was unaffected by the degree of practice. In other words, it seems that responses became quicker because either (a) extracting the valence of the target words or (b) mapping of valence and motor responses (or both) became more efficient. However, reversing the valence of a word did not become more efficient through practice.

Experiment 2

Even though results from Experiment 1 are consistent with our predictions, the present conclusions are contingent upon the assumption that the difference in response latencies for affirmed and

[1] Degrees of freedom were adjusted according to Greenhouse-Geisser where appropriate.

Table 1
Mean Response Latencies, Standard Errors, and Percentages of Error for Responses to Affirmed and Negated Words as a Function of Practice Block, Experiment 1

	Block					
Qualifier	1	2	3	4	5	6
Affirmation						
M	934.29	862.41	841.23	822.66	817.60	813.94
SEM	18.69	17.40	16.47	16.61	16.95	17.11
Error %	9.64	6.82	6.45	4.04	4.43	3.60
Negation						
M	1,034.42	963.11	947.20	924.74	924.81	917.46
SEM	20.49	18.97	18.28	18.22	22.71	21.02
Error %	14.51	11.47	9.37	8.50	8.32	6.88

negated targets truly reflects the speed of negation. Thus, Experiment 2 was designed to provide additional evidence that is independent from this measure. In this study, we investigated whether practice effects generalize to new, unpracticed instances. If practice effects leave responses to new, unpracticed items unaffected, this would provide additional support for our assumption that effects of practice are primarily driven by associative mechanisms of memory activation. In the present context, studying generalization seems important because memory-based automaticity is bound to the exemplars which were practiced and stored in memory, whereas general procedures are not (e.g., Logan, 1988; E. R. Smith et al., 1988).

In Experiment 2, the setup of Experiment 1 was used up to the fifth block of learning. Block 6, however, consisted of new, unpracticed affirmed and negated words. On the basis of the response-latency model outlined for Experiment 1 (see Figure 1), we predicted that the retrieval of word valence, as well as the mapping of valence and response keys, should become more efficient with practice. Hence, we expected response latencies to drop as a function of practice for both affirmed and negated words up to Block 5. However, the speed of valence reversal, and hence the difference between affirmed and negated trials, should remain constant. For Block 6, we expected that practice in valence-response mapping might to some degree transfer to the new items. However, participants' performance level in Block 6 should not reach the performance level in Block 5, because of the lack of prior valence activation for the new, unpracticed items. Most important, reversing the valence of words should not profit from training at all and, hence, should require the same amount of time in Block 6 as in all of the previous blocks. As such, the difference in response latencies for affirmed and negated items in Block 6 should be equal to those obtained in Blocks 1–5.

If, contrary to our reasoning, the obtained speed up in responding to affirmed and negated words was due to the strengthening of general procedures, this general skill should be transferable to the new items. In this case, responses to the new negated words should profit from the previous practice, whereas responses to the new affirmed words should not profit at all. As such, latencies for new affirmed words should be much closer to the performance in the early blocks than to the latencies for new negated blocks.

Method

Participants and Design

Thirty-three students of the University of Würzburg (25 women, 8 men) took part in a study purportedly concerned with attention and performance. Participants received €6 (approximately U.S. $5 at that time) as compensation. The experiment consisted of a 2 (word valence: positive vs. negative) × 2 (qualifier: affirmation vs. negation) × 5 (practice block: 1–5) within-subject design. In addition, we included a sixth block in which a new set of words was used.

Procedure

The present experiment lasted about 40 min and was part of a larger set of unrelated studies. The training phase was identical to that of Experiment 1 with one exception. Instead of practicing with the same set of affirmed and negated words in all six blocks, participants practiced with one set of words in Blocks 1–5, and then they were tested with a new set of words in Block 6.

Materials

The same 10 positive and 10 negative words as in Experiment 1 were randomly divided into two sets (Set A and Set B), each containing 5 positive and 5 negative words, which were then used either in Blocks 1–5 or in Block 6. In each block, every word was presented five times with an affirmation and five times with a negation. In one condition, participants practiced with Set A in Blocks 1–5 and received Set B in Block 6; in another condition, participants practiced with Set B in Blocks 1–5, and received Set A in Block 6.

Results

Incorrect responses (9.3%), anticipations (RT $<$ 300 ms, 0.1%), and the first response in each block were excluded from analyses. Replicating the findings obtained in Experiment 1, response latencies decreased as a negatively accelerated function of practice, reaching an asymptote of learning after Block 4 (see Figure 3). This conclusion is supported by the results of a 2 (word valence) ×

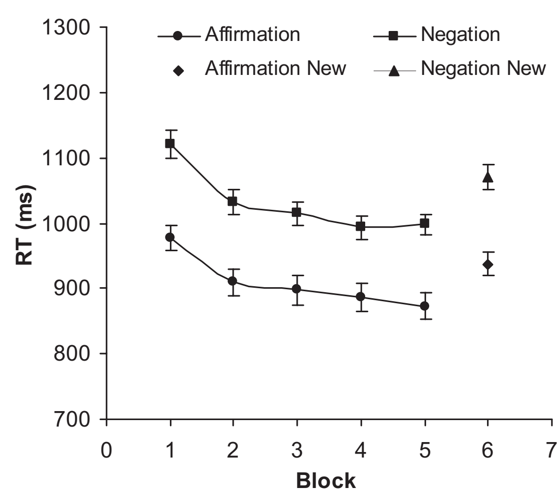

Figure 3. Response latencies to affirmed and negated words as a function of practice (Experiment 2). Error bars indicate the standard errors of the means. RT = response time.

2 (qualifier) × 5 (practice block) ANOVA for repeated measures,[2] which yielded a significant main effect for block, $F(4, 128) = 33.91$, $p < .001$, $\eta^2 = .51$. In addition, a significant main effect of qualifier indicated that response to negated words was generally slower than response to affirmed words, $F(1, 32) = 340.67$, $p < .001$, $\eta^2 = .91$. Most important, this effect was independent of practice, as reflected by the nonsignificant interaction of Block × Qualifier, $F(4, 128) = 1.61$, $p = .19$, $\eta^2 = .05$.

How did responses to new, unpracticed items profit from previous practice? Inspection of mean values indicates that performance for both affirmed and negated new items was somewhere in between the performances in Blocks 1 and 2 (see Table 2). This observation is supported by contrast analyses showing that latencies in Block 6 differed from all other blocks for both affirmed (all *F*s > 4.00, all *p*s < .06) and negated words (all *F*s > 5.40, all *p*s < .03). Most important, the increase in response latencies from Block 5 to Block 6 was identical for affirmed ($M = 6.54\%$, $SD = 7.49\%$) and negated ($M = 6.78\%$, $SD = 6.61\%$) new words, $F(1, 32) = 0.03$, $p = .86$, $\eta^2 < .01$. Likewise, the decrease in response latencies from Block 1 to Block 6 did not differ for affirmed ($M = 3.81\%$, $SD = 7.90\%$) and negated ($M = 4.10\%$, $SD = 8.46\%$) new words, $F(1, 32) = 0.04$, $p = .84$, $\eta^2 < .01$. An ANOVA on the cost of negation using block (1–6) as a within-subject factor yielded no significant main effect of block, $F(5, 160) = 1.47$, $p = .20$, $\eta^2 = .04$, suggesting that negation speed was unaffected by practice for both trained and untrained items.

Discussion

The results of Experiment 2 provide further evidence for the memory-based nature of practice effects on negating valence. Replicating the basic findings of Experiment 1, we observed a general speed up in responses to both affirmed and negated words from Block 1 to Block 5. At the same time, however, the difference in response latencies remained constant, indicating that the time required to reverse word valence was unaffected by practice. This pattern corroborates our assumption that the increased accessibility of word valence and stored valence–response associations were responsible for practice effects, whereas the general procedure to negate did not become more efficient by practice. The introduction of a sixth block, consisting of new, unpracticed targets provided further evidence for this notion. Consistent with our response-latency model (see Figure 1), responses in Block 6 were slightly faster than in Block 1. This transfer effect, however, was identical for affirmed and negated targets. If the general procedure of negating valence had become more efficient through practice, transfer effects should have been stronger for negated than for affirmed targets. The symmetrical nature of the transfer effect, however, indicates that transfer was solely due to stored valence–response associations in memory. In other words, Experiments 1 and 2 both demonstrated that responding to negated items becomes quicker with practice, which in itself might have been interpreted as evidence for an increase in the efficiency to negate. However, our data on generalization and the constant difference between responses toward affirmed and negated words indicate that the general procedure to negate did not become more efficient with extended practice. Rather, improvements in the skill to evaluate were driven by memory-based, content-specific mechanisms. Experiment 3 further demonstrates how content-based mechanisms can lead to performance levels that strongly resemble the speedup of an abstract procedure.

Table 2
Mean Response Latencies, Standard Errors, and Percentages of Error for Responses to Affirmed and Negated Words as a Function of Practice Block, Experiment 2

	Block					
Qualifier	1	2	3	4	5	6
Affirmation						
M	978.28	909.60	897.51	885.72	872.81	937.25
SEM	20.45	18.94	18.20	16.96	16.19	18.48
Error %	8.37	7.09	5.31	4.91	5.93	6.74
Negation						
M	1,120.71	1,032.55	1,014.89	993.00	997.94	1,070.81
SEM	19.14	20.21	22.86	21.12	20.90	18.48
Error %	17.91	13.89	12.24	8.80	10.04	13.59

Experiment 3

As indicated by Experiments 1 and 2, evaluating negated expressions requires the application of the general procedure to negate, and practice did not enhance the efficiency of this procedure. In Experiment 3, we tried to implement conditions that facilitate memory-based automaticity, thus making the general procedure obsolete. Such memory-based automaticity can be expected if practice creates associations between the representation of the stimuli and the correct solution in memory. For instance, the compound term *no way* is a frequently used expression in everyday English. As such, the meaning of this term may be activated in memory without applying the operation of negation. That is, the compound term may have acquired independent meaning in associative memory, which does not require controlled construal processes upon the perception of the two words. An infrequent negation, however, such as *no hay,* would still require the application of the negation (see Mayo et al., 2004). The training conditions in our first two experiments presumably prevented the compounds from acquiring a new meaning. Research by Schneider and Shiffrin (1977) suggested that automatic responding is most likely to occur if a stimulus is consistently paired with the same response. In the previous experiments, however, each word was processed equally often in an affirmed and a negated version, thus requiring directly opposing responses.

To facilitate the emergence of memory-based automatic processing of negations, we used a modified practice task in Experiment 3. Different from the previous experiments, each word appeared either in an affirmed or a negated manner during training, but never in both versions. For instance, one group of participants was presented the word *party* always with a negating qualifier (i.e., *no party*), but never with an affirming qualifier (i.e., *a party*). In a second condition, the same word always appeared in an affirmed manner, but never in a negated manner. This procedural change eradicates the inconsistent pairing of words and valence in mem-

[2] Degrees of freedom were adjusted according to Greenhouse-Geisser where appropriate.

ory, which was prevalent in the first two experiments. Consequently, we expected that participants would store the respective compound meanings together with their valence in associative memory. Thus, with increased practice, the compounds should be stored as new concepts in associative memory, and their evaluative meaning should be activated as easily as for affirmed compounds. Drawing on these considerations, we expected the difference between affirmed and negated trials to decrease as a function of practice under the conditions implemented in Experiment 3.

A problem of the proposed setup is, however, that participants may associate a given compound stimulus with the left-hand or the right-hand key without activating the specific valence. For instance, participants may learn that the compound *no party* always implies to press the right-hand key. Hence, seeing *no party* may become associated with right-hand key instead of negativity. To prevent such stimulus–key associations, the mapping of valence and key was changed from trial to trial. At the beginning of each trial, participants were informed whether they had to press the left (right) key if a positive (negative) expression appeared on the screen. Thereafter, the affirmed or negated word appeared, and participants had to press the appropriate key. This way, a given compound term was always associated with the same valence, but not with the same key.

Method

Participants and Design

Twenty-one psychology students (18 women, 3 men) of the University of Würzburg took part in the present study, purportedly on concentration. Participants received course credit for their participation. The experiment consisted of a 2 (word valence: positive vs. negative) × 2 (qualifier: affirmation vs. negation) × 6 (practice block: 1–6) within-subject design.

Procedure

The experiment took about 30 min and was conducted in group sessions with up to 3 participants. The procedure was identical to that of Experiment 1 with the following exceptions. To familiarize participants with the alternating valence-key mapping, we included a practice phase of 40 trials, in which participants repeatedly evaluated 10 positive and 10 negative nouns without qualifiers. Participants were instructed to evaluate the words as quickly as possible by pressing one of two keys, and they were informed about the alternating key assignment. Each trial started with the presentation of a warning signal (XXX) in the center of the screen for 200 ms. Immediately afterward, the words *positive* and *negative* were presented on the left and the right side of the letter string, indicating the key assignment for the upcoming trial. After 1,000 ms, a positive or negative target word was presented in the center of the screen. The key assignment and the target remained on the screen until participants responded. If participants responded correctly, the next trial started immediately, resulting in a response–stimulus interval of 1,200 ms. For incorrect responses, participants received error feedback (*Error!*), which remained on the screen for 1,500 ms. If participants did not respond within 2,000 ms, the trial was aborted and a warning message (*Try to respond faster!*) was displayed for 1,500 ms. Immediately after feedback for errors and slow responses, the next trial started, resulting in a feedback–stimulus interval of 1,200 ms. The actual training blocks were identical to the practice phase with two exceptions. Specifically, participants were presented compounds of new affirmed and negated words (instead of single words), and they were instructed to respond to the overall valence of the compound (instead of the valence of the single words). The critical learning phase consisted of six blocks. In each of the six blocks, each of five exemplars of the four types of stimuli (i.e., affirmed positive, affirmed negative, negated positive, negated negative) were presented five times, resulting in a total of 100 trials per block.

Materials

For the practice phase, 10 positive and 10 negative words (see Appendix C) were selected from a standardized list of positive and negative words published by Klauer and Musch (1999). For the critical training blocks, the same 10 positive and 10 negative words as in Experiment 1 were randomly divided into two sets (Set A and Set B), each consisting of 5 positive and 5 negative words. In one experimental condition, all words from Set A were presented in a negated form, and all words from Set B were presented in an affirmed manner. In a second condition, the set assignment was reversed.

Results

Incorrect responses (7.0%), anticipations (RT < 300 ms, 0.04%), and the first reaction in each block was excluded from analyses. Even though the overall response latencies were much longer than in the previous two studies (most likely because of the newly implemented key switching), RTs decreased as a negatively accelerated function of practice (see Figure 4). Different from the previous studies, however, only responses to affirmed stimuli reached asymptotic learning, whereas the responses to negated stimuli continued to become quicker up to the last block. Although responses to negated stimuli again took considerably longer than responses to affirmed stimuli, this difference was reduced by practice. These interpretations are supported by the results of a 2 (word valence) × 2 (qualifier) × 6 (practice block) ANOVA for

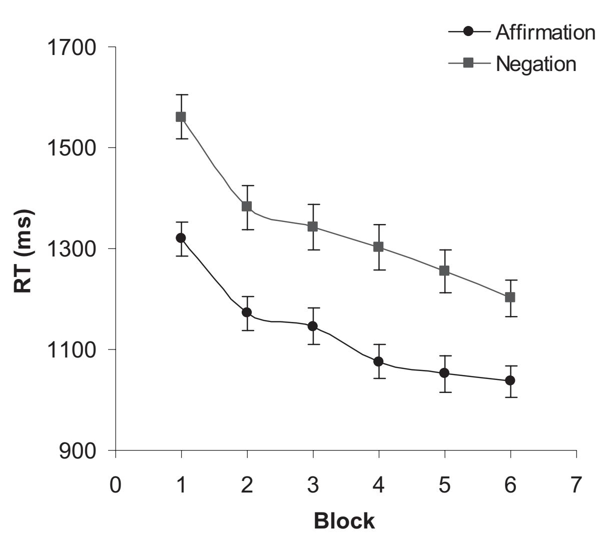

Figure 4. Response latencies to affirmed and negated words as a function of practice (Experiment 3). Error bars indicate the standard errors of the means. Note that because of longer response latencies, the scaling differs from Figures 2 and 3. RT = response time.

Table 3
Mean Response Latencies, Standard Errors, and Percentages of Error for Responses to Affirmed and Negated Words as a Function of Practice Block, Experiment 3

	Block					
Qualifier	1	2	3	4	5	6
Affirmation						
M	1,319.12	1,171.45	1,145.72	1,075.87	1,051.31	1,036.33
SEM	33.18	34.26	35.60	33.24	36.11	31.15
Error %	6.82	5.73	5.14	5.06	5.60	5.62
Negation						
M	1,560.96	1,381.27	1,342.38	1,303.24	1,254.20	1,202.34
SEM	44.28	43.60	44.91	44.53	42.40	36.18
Error %	10.54	8.97	6.94	8.23	8.07	8.89

repeated measures,[3] which yielded a significant main effect for block, $F(5, 100) = 51.01$, $p < .001$, $\eta^2 = .72$; a significant main effect of qualifier, $F(1, 20) = 113.91$, $p < .001$, $\eta^2 = .85$; and most important, a significant interaction of Qualifier × Block, $F(5, 100) = 2.55$, $p = .032$, $\eta^2 = .11$ (see Table 3). Simple contrasts revealed significant learning effects for affirmed stimuli up to Block 4 (except for the contrast between Blocks 2 and 3; all Fs > 11.00, all ps < .03), but not for the last two blocks (all Fs < 2.70, all ps ≥ .1). For negated stimuli, on the other hand, all contrasts (except for the one between Blocks 4 and 5) were significant (all Fs > 4.00, all ps < .051). To further specify the significant interaction, we computed the cost of reversing word valence by subtracting the latencies of affirmed trials from the latencies of negated trials as a function of the six blocks. Contrast analyses revealed a significant decrease in the cost of negation from Blocks 1–6, $F(1, 20) = 13.23$, $p = .002$, $\eta^2 = .40$; Blocks 4–6, $F(1, 20) = 7.80$, $p = .01$, $\eta^2 = .28$; and Blocks 5–6, $F(1, 20) = 4.57$, $p = .04$, $\eta^2 = .19$, and the overall linear contrast was significant too, $F(1, 20) = 9.10$, $p = .007$, $\eta^2 = .31$.

As with Experiment 1, word valence influenced response times in several ways. First, negative words ($M = 1,259$, $SD = 150$) were evaluated more slowly than positive words ($M = 1,215$, $SD = 159$), $F(1, 20) = 29.88$, $p < .001$, $\eta^2 = .60$. This main effect of word valence was qualified by an interaction with the qualifier, indicating that negative words were processed slower only when they were affirmed ($M_{negative} = 1,185$, $SD_{negative} = 149$ vs. $M_{positive} = 1,081$, $SD_{positive} = 129$), but not when they were negated ($M_{negative} = 1,333$, $SD_{negative} = 162$ vs. $M_{positive} = 1,349$, $SD_{positive} = 208$), $F(1, 20) = 16.46$, $p = .001$, $\eta^2 = .45$. Finally, the interaction of Valence × Block reached significance, $F(5, 100) = 2.81$, $p = .020$, $\eta^2 = .12$, indicating that responses to negative stimuli were slower in Blocks 1, 3, and 5, whereas no difference occurred in the remaining blocks.

Discussion

The results of Experiment 3 indicate that evaluating negated expressions can be driven by memory retrieval instead of the application of the procedure to negate. Different from Experiments 1 and 2, word stimuli in Experiment 3 appeared either in an affirmed or in a negated manner in the training blocks. This way, the storing of the compound stimulus along with its overall valence in associative memory was assumed to be facilitated. The data indeed support this notion. As in the previous experiments, training generally reduced response latencies toward affirmed and negated stimuli. Different from the previous experiments, however, the reduction was not symmetrical for affirmed and negated words. In particular, negated words profited more from the training than affirmed words. This asymmetry was indicated by asymptotic learning curves for affirmed words but not for negated words. Moreover, unlike in the previous experiments, the difference between response latencies to affirmed and negated words decreased as a function of practice. This result suggests that, with extended practice, participants stored the overall valence of the negated expressions in memory and were thus able to retrieve them directly with greater efficiency. As such, the cost of negating a given compound declined as a function of practice.

Even though Experiments 1–3 are consistent with our prediction, one might object that the mental operation to reverse the valence of a word is frequently used in everyday language and thinking. Therefore, the level of efficiency may have already reached a maximum, which cannot be altered by further training. According to this reasoning, the failure to observe a decrease in the time of negating valence may simply be a floor effect, because negating might already be an automatic skill. If this assumption is correct, negation should operate independent from intention (see Shiffrin & Dumais, 1981) and cognitive capacity. In contrast to this interpretation, however, the processing of negations has been shown to put substantial stress on the cognitive system (Lea & Mulligan, 2002; see also Gilbert, 1991). For instance, logical reasoning becomes slower and more prone to error if negations are part of premises or conclusions (e.g., Evans, Newstead, & Byrne, 1993; Wason, 1959). In a similar vein, psycholinguistic research has indicated that the meaning of sentences containing negations requires the construction of mental models that describe the situation implied by the negation (e.g., Kaup, 2001; Lea & Mulligan, 2002). Finally, a recent study by Mayo et al. (2004) indicated that it is easier to determine whether a given fact (e.g., *Tom's clothes are folded neatly in his closet*) indicates the presence of a personality trait (e.g., *Tom is a tidy person*) as opposed to the absence of this trait (e.g., *Tom is not a tidy person*). However, even though

[3] Degrees of freedom were adjusted according to Greenhouse-Geisser where appropriate.

these studies suggested that processing negations is relatively inefficient, they were not conclusive regarding the question of whether the processing of negations can take place independent from intentions. Experiments 4–6 were designed to answer this question more directly.

Experiment 4

In Experiments 1 and 2, extensive training did not increase the efficiency of the procedure to negate the valence of a word. If this lack of increase was due to a floor effect—caused by the extensive practice of negations in everyday language processing and reasoning—processing negations should be relatively efficient and independent from intentions. According to the present hypotheses, however, processing negations should be both relatively inefficient and dependent on intentions. Although existing evidence is incompatible with the first assumption (see Gilbert, 1991), there is little evidence addressing the second assumption. In Experiment 4, we tested our prediction by comparing evaluative priming effects of negated or affirmed positive and negative stimuli to deliberate evaluative judgments of the same stimuli. In evaluative priming paradigms (Fazio et al., 1986), a prime stimulus is presented briefly (usually for less than 300 ms) before the presentation of a target word. The participants' task is to indicate the valence of the target word. The evaluation of the target word is usually facilitated if the valence of the prime and the target are congruent. However, the evaluation of the target word is usually inhibited if the valence of the prime and the target are incongruent. Most important, such evaluative priming effects emerge even though participants are not required to process the valence of the prime stimulus. Thus, if the processing of negations is indeed highly efficient and independent from intentions, negated prime stimuli should not only activate the word valence in memory, but also lead to an immediate reversal of the activated valence. Accordingly, priming effects of positive and negative prime words should differ as a function of whether they are affirmed or negated. That is, affirmed positive and negated negative prime words should lead to positive evaluative priming effects, whereas negated positive and affirmed negative prime words should lead to negative evaluative priming effects. However, if our assumption is correct that the processing of negations requires intention, priming effects of positive and negative prime words should not differ as a function of whether they are affirmed or negated. That is, both affirmed and negated positive prime words should lead to positive evaluative priming effects, whereas both affirmed and negated negative prime words should lead to negative evaluative priming effects.

Whereas most priming paradigms (Fazio et al., 1986; Neely, 1977) use only one prime stimulus, the research question addressed in the present experiment requires the presentation of two primes (i.e., qualifier and concept). Thus, a paradigm capable of capturing the preconstructive effects of two stimuli was required. Balota and Paul (1996) used a sequential priming paradigm to explore the joint operation of multiple primes in a semantic priming task. They expected that if two primes are semantically related to a target (e.g., *stripes* and *cage* as primes and *tiger* as target), a stronger priming effect should occur compared with a situation in which only one or none of the two primes is related to the target (e.g., *beans* and *dance* as primes and *tiger* as target). To test this prediction, Balota and Paul sequentially presented two primes, 133 ms each with a 33-ms interval between the last prime and target onset, resulting in a stimulus onset asynchrony (SOA) of 299 ms. Using this paradigm, Balota and Paul found that responses to target words are fastest if both primes are related to the target and slowest if both primes are unrelated to the target, with conditions in which one prime is related to the target falling in between.

This paradigm also seems suitable for the present purpose of assessing the joint effects of different qualifiers and different target concepts. More precisely, we used either affirming or negating qualifiers as the first of two sequentially presented primes and positive or negative words as the second primes in an affective priming paradigm adapted from Fazio et al. (1986). In addition, we assessed participants' reflective evaluations of affirmed and negated prime stimuli. Although in this evaluative judgment task the presentation of the affirmed and negated words was exactly the same as in the evaluative priming task, it additionally involved the intention to process the valence of the compound term, thus warranting a successful processing of the negation. There were four types of qualifier–word pairings: affirmed positive (e.g., *a party*), negated positive (e.g., *no party*), affirmed negative (e.g., *a disease*), and negated negative (e.g., *no disease*).

Method

Participants and Design

Thirty-seven students (25 women, 12 men) of the University of Würzburg took part in a study purportedly concerned with concentration. Participants received €6 as compensation (approximately U.S. $5 at that time). The experiment consisted of a 2 (word valence: positive vs. negative) × 2 (qualifier: affirmation vs. negation) × 2 (measure: evaluative judgment vs. evaluative priming) within-subject design.

Procedure

Practice trials. Participants first practiced the evaluation of the target words without primes. Half of the participants were instructed to press the left key as fast as possible if the word was positive and to press the right key if the word was negative. For the remaining half of participants, the key assignment was reversed. Each target word was presented once, resulting in a total of 20 practice trials. Each trial started with a warning signal (* * *) in the center of the screen for 500 ms, followed by a blank screen for 500 ms. The target word was then presented in the center of the screen in uppercase letters and bright yellow color. As soon as participants pressed the correct key, the reaction was recorded and the next trial started, resulting in a response–stimulus interval of 1,000 ms. If participants pressed the wrong key, appropriate error feedback (e.g., *Error! Positive left, negative right*) appeared on the screen for 1,000 ms. Then the next trial started, resulting in a feedback-stimulus interval of 1,000 ms.

Evaluative priming task. After the practice trials, participants learned that the following task would be similar to the previous one, with the exception that they would see two additional words in white letters for a brief time before the yellow target words appear on the screen. Participants were told to focus particularly on the yellow words and to ignore the white words. As in the practice trials, the key assignment for categorization responses was varied between participants. Primes and targets were matched randomly for each participant and trial. Each prime combination was presented once with a positive and once with a negative target, resulting in a total of 80 priming trials, representing a 2 (first prime qualifier: affirmation vs. negation) × 2 (second prime valence: positive vs. negative) × 2 (target valence: positive vs. negative) within-subject subdesign.

Priming trials were identical to the practice trials with the following exceptions. After the warning signal, either an affirmation (i.e., *a*) or negation (i.e., *no*) term was presented for 133 ms in the center of the screen in white uppercase letters, which was immediately followed by either a positive or negative word for 133 ms, also in white letters. A blank screen then replaced the second prime. After 33 ms the target word appeared on the screen, which was presented in yellow uppercase letters.

Evaluative judgment task. After the priming task, participants were told that they would again see the white words that were used as primes in the previous block and that their task was to judge the valence of these pairs of words on a 5-point rating scale ranging from 1 (*very bad*) to 5 (*very good*). They were explicitly asked to take as much time as they wanted to make their judgment. The same 40 qualifier–words pairings as in the priming task were used, resulting in a total of 40 trials for the judgment task. The order of stimulus presentation was randomized for each participant. The procedure for each trial was the same as the priming trials, except that no target words were presented. Instead, the rating scale followed the presentation of each prime combination. Also, because of the usage of a judgment scale instead of positive–negative decision, error feedback was omitted.

Materials

For this and the following experiment, words were selected from a standardized list of positive and negative words published by Klauer and Musch (1999). To generate prime stimuli, 10 positive and 10 negative nouns were selected on the basis of their evaluative extremity. These 20 nouns were presented together with qualifiers indicating an affirmation or negation (i.e. *a*, *no*), resulting in a total of 40 different qualifier (Prime 1) and word (Prime 2) combinations (see Appendix D). In addition to the prime words, we selected 10 positive and 10 negative nouns from Klauer and Musch's (1999) list to be chosen as target words for the evaluative priming task (see Appendix E).

Results

For the analyses of the evaluative priming data, latencies of incorrect responses (2.3%) and all response latencies higher than 1,000 ms (5.4%) were excluded.[4] To simplify the comparison between evaluative priming and evaluative judgment data, we calculated positivity indices for each of the four prime combinations (i.e., affirmed positive, affirmed negative, negated positive, negated negative) by subtracting the latencies for positive targets from the latencies for negative targets, given a specific prime combination (for absolute response latencies, see Table 4). The resulting positivity indices of the evaluative priming task, as well as positivity ratings of the evaluative judgment task, were then *z* transformed, based on the distribution of each measure. These scores were then submitted to a 2 (word valence) × 2 (qualifier) × 2 (measure) ANOVA for repeated measures. As expected, negations had a differential impact on evaluative judgments as compared with evaluative priming. Whereas negations reversed the valence of words for in the evaluative judgment task (see Figure 5, right panel), the positivity index for the evaluative priming task was unaffected by the negations (see Figure 5, left panel). This result is reflected in a highly significant three-way interaction of Word Valence × Qualifier × Measure, $F(1, 36) = 182.29$, $p < .001$, $\eta^2 = .84$. To further specify the nature of this interaction, we conducted separate analyses for each measure.

A 2 (word valence) × 2 (qualifier) ANOVA on evaluative judgments revealed a significant main effect of word valence, $F(1, 36) = 10.62$, $p = .002$, $\eta^2 = .29$, and more important, a highly significant interaction between valence and qualifier, $F(1, 36) = 172.80$, $p < .001$, $\eta^2 = .83$. Simple contrasts indicated that affirmed positive words ($M = 4.30$, $SD = 0.59$) were evaluated more positively than affirmed negative words ($M = 1.89$, $SD = 0.50$), $F(1, 36) = 219.82$, $p < .001$, $\eta^2 = .86$, and that negated positive words ($M = 2.21$, $SD = 0.69$) were evaluated more negatively than negated negative words ($M = 3.89$, $SD = 0.71$), $F(1, 36) = 59.21$, $p < .001$, $\eta^2 = .62$. Moreover, affirmed positive words were evaluated as more positive than negated negative words, $F(1, 36) = 7.85$, $p = .004$, $\eta^2 = .21$, and negated positive words were evaluated as less negative than affirmed negative words, $F(1, 36) = 7.85$, $p = .004$, $\eta^2 = .18$.

The same ANOVA on positivity indices of the evaluative priming task revealed a significant main effect for word valence, $F(1, 36) = 29.62$, $p < .001$, $\eta^2 = .45$, indicating that positive prime words ($M = 12.08$, $SD = 39.45$) showed a more positive valence than negative prime words ($M = -28.84$, $SD = 48.15$). Most important, this effect was independent of the qualifier, as indicated by a nonsignificant interaction between qualifier and valence ($F < 1$). Also, the main effect of the qualifier was not significant $F(1, 36) = 2.12$, $p = .154$, $\eta^2 = .06$. Simple contrasts further indicated that affirmed positive words ($M = 3.89$, $SD = 47.49$) had a more positive valence than affirmed negative words ($M = -35.00$, $SD = 53.49$), $F(1, 36) = 14.37$, $p = .001$, $\eta^2 = .26$, and that negated positive words ($M = 20.27$, $SD = 50.96$) had a more

Table 4
Mean Response Latencies, Standard Errors, and Percentages of Error for Responses to Positive and Negative Target Words as a Function of Prime Valence and Qualifier Attached to Prime, Experiment 4

	Prime valence	
Target valence	Positive	Negative
Prime qualifier: Affirmation		
Positive		
M	616.84	639.97
SEM	12.86	11.15
Error %	1.35	4.80
Negative		
M	620.73	604.96
SEM	12.08	12.96
Error %	2.85	1.42
Prime qualifier: Negation		
Positive		
M	605.87	630.11
SEM	13.16	12.95
Error %	2.15	1.95
Negative		
M	626.14	607.43
SEM	12.20	12.27
Error %	2.16	1.89

[4] As proposed by Ratcliff (1993), the results of the main analyses were validated with a second analysis, in which the data were trimmed by an inverse transformation of the raw response latencies instead of a cut-off procedure. Analyses with both data sets revealed corresponding results.

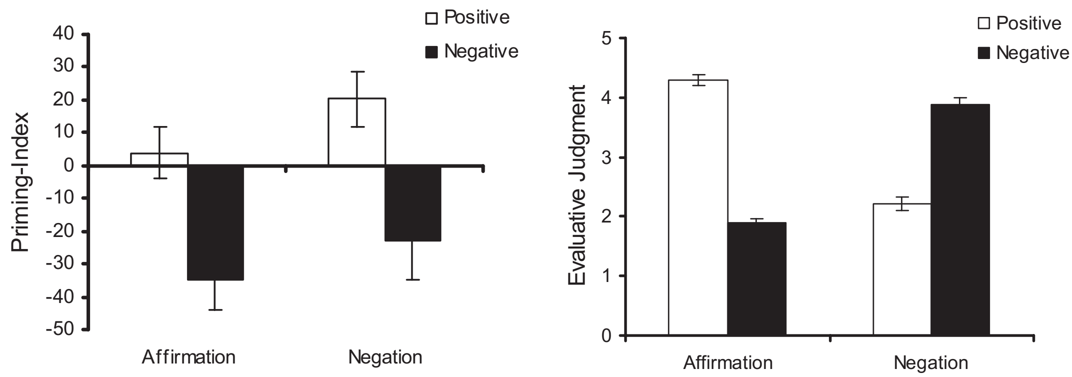

Figure 5. Mean evaluative priming (left) and evaluative judgment effects (right) as a function of word valence and qualifier (Experiment 4). Higher values indicate more positive valence. Error bars indicate standard errors of the mean.

positive valence than negated negative words ($M = -22.68$, $SD = 74.06$), $F(1, 36) = 17.12$, $p < .001$, $\eta^2 = .32$. The valence of affirmed negative and negated negative words did not differ from each other, $F(1, 36) = 0.76$, $p = .39$, $\eta^2 = .02$. The same was true for the valence of affirmed positive and negated positive words $F(1, 36) = 2.85$, $p = .10$, $\eta^2 = .07$.

Discussion

The results of Experiment 4 support our assumption that the findings obtained in Experiments 1–3 are due to genuine differences in the processing of affirmations and negations, rather than to a high efficiency level in the processing of negations. Specifically, one could argue that the mental operation to reverse the valence of a word is very frequent in everyday language and thinking, thus leading to floor effects in the time required for processing negations. This assumption is clearly inconsistent with the present findings. In the present study, negations influenced only reflective evaluations in an evaluative judgment task. However, unintentional evaluations obtained in an evaluative priming task (Fazio et al., 1986) were generally unaffected by the respective qualifiers. That is, positive prime words showed a more positive valence than negative prime words irrespective of whether these words were affirmed or negated. This pattern is in contrast to the notion that negations may already be trained to a degree such that further training could not increase their efficiency. If this was the case, negations should not only alter evaluative judgments but also evaluative priming effects. The evaluative judgment task additionally demonstrated that the presentation times of the primes were sufficient to process the two primes. In this task, qualifier and prime valence showed a highly significant interaction effect. Therefore, it can be ruled out that negations were ineffective because they were presented too briefly.

There are, however, two possible objections which may question the conclusions drawn from Experiment 4. First, one might argue that the qualifiers (Prime 1) did not affect automatic processing because they were presented much earlier than the prime words (Prime 2). As such, activated representations in memory may have faded away before the target presentation. Research by Hermans, De Houwer, and Eelen (2001), for example, indicated that evaluative priming effects strongly depend on the SOA. According to their experiments, priming effects reach their maximum with a prime presentation time of 200 ms and an SOA well below 300 ms. Thus, although Balota and Paul (1996) were successful in showing joint effects of two primes in this paradigm, the timing may be insufficient to show priming effects with abstract qualifiers. Second, the degree of automatization of a particular procedure may depend on the degree of practice (Bargh, 1997). Thus, even though negations are extensively practiced in everyday language, the usual way of processing negations in written language of participants' mother tongue is to read them from left to right. As such, it is possible that negations can be processed automatically if the respective stimuli are presented in a more common format. Experiment 5 was designed to rule out these two objections by presenting qualifiers and words in a parallel rather than in a sequential manner.

Experiment 5

To prevent qualifiers from being more distant to the targets than the prime words, qualifier–word combinations were presented simultaneously instead of sequentially. The use of compound primes also ensured that the primes were perceived similar as in everyday reading. Additionally, the SOA and presentation times were chosen so that a maximum priming effect could be expected (see Hermans et al., 2001). As in Experiment 4, we added an evaluative judgment condition to study reflective effects.

Method

Participants and Design

Thirty-one students (17 women, 14 men) of the University of Würzburg took part in a study purportedly dealing with concentration and attention. Participants received either €6 (approximately U.S. $5 at that time) or course credit as compensation. The experiment consisted of a 2 (word valence: positive vs. negative) × 2 (qualifier: affirmation vs. negation) × 2 (measure: evaluative judgment vs. evaluative priming) within-subject design.

Procedure

The stimulus material and procedure were identical to those in Experiment 4 with the following exceptions. Instead of the particular key assignment being varied between participants, the key assignment was now manipulated on a within-subject basis. The order of key assignment was counterbalanced. Because of the within-variation of the key assignment, the 40 qualifier-word combinations were used twice as primes with positive and negative targets, resulting in a total of 160 priming trials. More important, qualifiers and words were presented in parallel (rather than sequentially). Each trial started with a warning signal (* * *) in the center of the screen for 500 ms. After a blank screen for 200 ms, the prime words were displayed for 200 ms. Immediately afterward, the target words appeared on the screen, resulting in an SOA of 200 ms. Because of the slightly reduced interval between the warning and prime presentation, the feedback-stimulus and response-stimulus intervals were only 700 ms. Instructions for the task were adapted accordingly. The evaluative judgment task was identical to Experiment 4, except that the presentation of stimuli was adapted to the parallel priming procedure.

Results

For the analyses of the evaluative priming data, latencies of trials in which participants incorrectly classified the target (3.9%) and all response latencies greater than 1,000 ms (8.0%) were excluded.[5] Indices of positivity were calculated according to the procedure described in Experiment 4 (for absolute response latencies, see Table 5). The resulting positivity indices of the evaluative priming task as well as positivity ratings of the evaluative judgment task were then *z* transformed, based on the distribution of each measure. These scores were then submitted to a 2 (word valence) × 2 (qualifier) × 2 (measure) ANOVA for repeated measures. Consistent with our predictions, evaluative judgments and evaluative priming effects were differentially affected by the qualifiers. This result is reflected in a highly significant three-way interaction of Word Valence × Qualifier × Type of Measure, $F(1, 30) = 751.48$, $p < .001$, $\eta^2 = .96$ (see Figure 6). To further specify the nature of this interaction, we conducted separate analyses for each measure.

Table 5
Mean Response Latencies, Standard Errors, and Percentages of Error for Responses to Positive and Negative Target Words as a Function of Prime Valence and Qualifier Attached to Prime, Experiment 5

Target valence	Prime valence: Positive	Prime valence: Negative
Prime qualifier: Affirmation		
Positive		
M	616.11	626.70
SEM	10.91	10.02
Error %	2.90	3.75
Negative		
M	637.45	621.02
SEM	12.49	10.50
Error %	4.45	4.75
Prime qualifier: Negation		
Positive		
M	615.40	633.41
SEM	10.37	11.44
Error %	2.97	4.64
Negative		
M	637.29	636.94
SEM	12.12	11.17
Error %	4.02	3.32

Replicating the results of Experiment 4, a 2 (word valence) × 2 (qualifier) ANOVA on evaluative judgments revealed a significant main effect of word valence, $F(1, 30) = 22.84$, $p < .001$, $\eta^2 = .43$; a significant main effect of the qualifier, $F(1, 30) = 33.93$, $p < .001$, $\eta^2 = .53$; and more important, a highly significant interaction of Word Valence × Qualifier, $F(1, 30) = 917.33$, $p < .001$, $\eta^2 = .97$. Simple contrasts indicate that participants evaluated affirmed positive words ($M = 4.59$, $SD = 0.29$) more positively than affirmed negative words ($M = 1.85$, $SD = 0.29$), $F(1, 30) = 1171.65$, $p < .001$, $\eta^2 = .97$. Conversely, negated negative words ($M = 4.00$, $SD = 0.45$) were evaluated more positively than negated positive words ($M = 1.76$, $SD = 0.30$), $F(1, 30) = 404.21$, $p < .001$, $\eta^2 = .93$. Even though negated negative words were seen as less positive than affirmed positive words, $F(1, 30) = 48.02$, $p < .001$, $\eta^2 = .66$, negated positive words were rated equally negative as affirmed negative words, $F(1, 30) = 1.65$, $p = .21$, $\eta^2 = .05$.

The same ANOVA on positivity indices of the evaluative priming task revealed a significant main effect only for word valence, $F(1, 30) = 12.66$, $p = .001$, $\eta^2 = .30$, indicating that positive words ($M = 21.61$, $SD = 29.58$) showed a more positive valence than negative words ($M = -1.07$, $SD = 32.99$). Most important, this effect was again independent of the qualifier, as indicated by a nonsignificant interaction between Qualifier × Valence ($F < 1$). Simple contrasts further revealed that negated positive primes ($M = 21.88$, $SD = 38.89$) tended to have a more positive valence than negated negative primes ($M = 3.53$, $SD = 46.82$), $F(1, 30) = 3.12$, $p = .09$, $\eta^2 = .09$. Correspondingly, affirmed positive primes ($M = 21.34$, $SD = 31.80$) had a more positive valence than affirmed negative primes ($M = -5.68$, $SD = 35.11$), $F(1, 30) = 12.70$, $p = .001$, $\eta^2 = .30$. In addition, affirmed positive words showed a more positive valence than negated negative words, $F(1, 30) = 4.19$, $p < .05$, $\eta^2 = .12$, and affirmed negative words showed a less positive valence than negated positive words, $F(1, 30) = 14.64$, $p = .001$, $\eta^2 = .33$.

Discussion

Experiment 5 confirms our assumption that the results of Experiment 4 are due to genuine effects related to the processing of negations, rather than to contingent features of the stimulus presentation. Specifically, Experiment 5 aimed to rule out the objective that the ineffectiveness of negations in the priming task of Experiment 4 was due to the unfamiliar presentation of negations and their temporal distance to the target. In the present study, qualifiers and positive and negative prime words were presented simultaneously at presentation times and SOAs that are optimal for automatic evaluative priming effects. Replicating the results of Experiment 4, negations only influenced responses in the evaluative judgment task. However, unintentional evaluations in the evaluative priming task (Fazio et al., 1986) were generally unaffected by relevant qualifiers. In this task, positive prime words showed a more positive valence than negative prime words, irre-

[5] As with Experiment 4, the results of the main analyses were validated with a second analysis, in which the data were trimmed by an inverse transformation of the raw response latencies instead of a cut-off procedure (cf. Ratcliff, 1993). Analyses with both data sets revealed corresponding results.

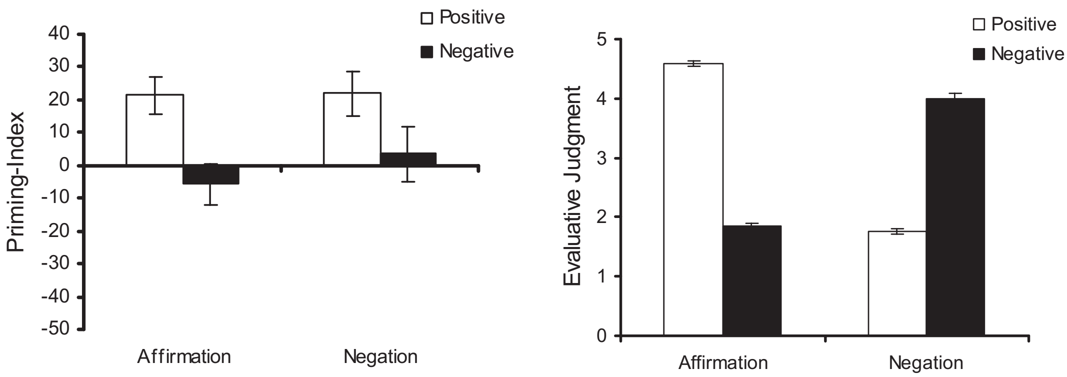

Figure 6. Mean evaluative priming (left) and evaluative judgment effects (right) as a function of word valence and qualifier (Experiment 5). Higher values indicate more positive valence. Error bars indicate standard errors of the mean.

spective of whether these words were affirmed or negated. As such, it is quite unlikely that the inefficiency of negations in the two priming studies were caused by a lack of familiarity with the particular kind of presentation (i.e., parallel vs. sequential) or by the temporal distance between qualifier and target in sequential presentations. The next experiment was devised to explore how the familiarity of specific negations influences evaluative priming effects.

Experiment 6

Experiments 4 and 5 suggest that, in line with our main hypothesis, processing time and intention are necessary prerequisites for the general procedure to negate valence. Experiment 6 was designed to further illustrate the role of instance learning in the negation of valence. Paralleling Experiment 3, we sought to establish conditions under which memory-based mechanisms would strongly resemble the output of the original procedure to negate. Theories of memory-based automaticity predict that the meaning of specific negations can be stored in memory through frequent practice. Consequently, if a highly practiced negation is perceived later, the compound meaning implied by the negation will be activated automatically and will thereby influence further processing. If this reasoning is correct, the immediate effects of highly trained negations should differ considerably from those of untrained, novel negations. Experiment 6 tested this assumption by comparing the evaluative priming effects of negations that are frequent in everyday language (e.g., *no luck*) with those elicited by rare negations (e.g., *no cockroach*). As in the previous experiments, participants also judged the valence of the stimuli used as primes.

Method

Participants and Design

Fifty-five students (38 women, 17 men) of the University of Würzburg took part in an experiment purportedly concerned with concentration. Participants received €6 as compensation (approximately U.S. $5 at that time). The experiment consisted of a 2 (word valence: positive vs. negative) × 2 (frequency: frequent vs. rare) × 2 (measure: evaluative judgment vs. evaluative priming) within-subject design. In contrast to the previous experiments, only negated stimuli were used for the analyses in Experiment 6 (see below).

Procedure

The procedure and instructions were the same as in Experiment 5 except for the following deviations. First, the key assignment was manipulated between rather than within participants. Second, participants were primed twice with each of the frequent and rare negations, resulting in a total of 80 priming trials. In addition, affirmed versions of the stimuli were entered as filler stimuli to keep the overall structure of the materials comparable with Experiments 4 and 5. This added another 80 trials. However, because the frequency and valence data were obtained for the negated forms only, affirmations were generally excluded from analyses. Third, some new target words were used, because the previous set contained words identical to the selected rare and frequent negations. The procedure for the evaluative judgment task was identical to that of Experiment 5, except for the variations in the stimuli.

Materials

To identify frequent and rare negations of positive and negative words, we selected 53 positive and 53 negative words on rational grounds (see Experiment 1). Seventy-one psychology students evaluated these negations with respect to their frequency and their valence. On the basis of these data, 40 negations were chosen, 10 for each of the following categories: frequent negations of positive words, frequent negations of negative words, rare negations of positive words, and rare negations of negative words (see Appendix F for the words and Appendix H for pretest data). In addition to the prime words, we selected 10 positive and 10 negative nouns from Klauer and Musch's (1999) list to be chosen as target words for the evaluative priming task (see Appendix G).

Results

For the analyses of the evaluative priming data, latencies of trials in which participants incorrectly classified the target (3.8%) and all response latencies greater than 1,000 ms (5.9%) were excluded from analyses.[6] Indices of positivity were calculated according to the procedure described in Experiment 4 (for absolute response latencies, see Table 6). Consistent with our predictions, a

[6] As with Experiments 4 and 5, the results of the main analyses were validated with a second analysis, in which the data were trimmed by an inverse transformation of the raw response latencies instead of a cut-off procedure (cf. Ratcliff, 1993). Analyses with both data sets revealed corresponding results.

Table 6
Mean Response Latencies, Standard Errors, and Percentages of Error for Responses to Positive and Negative Target Words as a Function of Prime Valence and Qualifier Attached to Prime, Experiment 6

	Prime valence	
Target valence	Positive	Negative
Frequent negations		
Positive		
M	605.84	597.94
SEM	8.81	8.92
Error %	5.32	3.64
Negative		
M	596.07	607.94
SEM	8.16	8.59
Error %	3.97	4.41
Rare negations		
Positive		
M	599.40	615.23
SEM	8.96	8.65
Error %	2.61	4.95
Negative		
M	607.52	607.21
SEM	8.65	9.81
Error %	3.72	2.91

2 (word valence) × 2 (frequency) × 2 (measure) ANOVA revealed a highly significant three-way interaction, $F(1, 54) = 21.07$, $p < .001$, $\eta^2 = .28$ (see Figure 7). To further specify the nature of this interaction, we conducted separate analyses for each measure.

A 2 (frequency) × 2 (word valence) ANOVA on evaluative judgments revealed a significant main effect of valence, indicating that participants evaluated negated negative words more positively than negated positive words, $F(1, 54) = 1{,}364.67$, $p < .001$, $\eta^2 = .96$. In addition, frequent negations were evaluated less positively than rare negations, $F(1, 54) = 8.47$, $p = .005$, $\eta^2 = .14$. Moreover, frequency and word valence revealed a significant interaction, $F(1, 54) = 73.59$, $p < .001$, $\eta^2 = .58$, showing that frequent negations of positive words ($M = 1.50$, $SD = 0.36$) were evaluated more negatively than frequent negations of negative words ($M = 4.46$, $SD = 0.31$), $F(1, 54) = 1{,}574.85$, $p < .001$, $\eta^2 = .97$. Similarly, rare negations of positive words ($M = 1.97$, $SD = 0.36$) were evaluated more negatively than rare negations of negative words ($M = 4.21$, $SD = 0.42$), $F(1, 54) = 629.74$, $p < .001$, $\eta^2 = .92$. Moreover, negated negative words were evaluated more positively when they were frequent rather than rare negations, $F(1, 54) = 14.28$, $p < .001$, $\eta^2 = .21$, whereas negated positive words were evaluated more negatively when the negations were frequent rather than rare negations, $F(1, 54) = 108.36$, $p < .001$, $\eta^2 = .67$.

The same ANOVA on positivity indices of the evaluative priming task revealed a significant interaction between frequency and valence, $F(1, 54) = 9.80$, $p = .003$, $\eta^2 = .15$. As expected, rare negations were generally unaffected by negations, whereas the valence of the prime words was reversed for frequent negations. Neither the main effect of word valence nor the main effect of frequency was significant (both *F*s < 1). Further inspection revealed that for negations low in frequency, negated positive words ($M = 8.12$, $SD = 49.14$) tended to show a more positive valence than negated negative words ($M = -8.02$, $SD = 48.91$), $F(1, 54) = 3.47$, $p = .07$, $\eta^2 = .15$. For negations high in frequency, in contrast, negated negative words ($M = 9.90$, $SD = 43.48$) showed a more positive valence than negated positive words ($M = -9.68$, $SD = 57.23$), $F(1, 54) = 5.29$, $p = .03$, $\eta^2 = .09$. In addition, frequently negated negative words showed a more positive valence than rarely negated negative words, $F(1, 54) = 4.96$, $p = .03$, $\eta^2 = .08$, whereas frequently negated positive words tended to show a more negative valence than rarely negated positive words, $F(1, 54) = 3.21$, $p = .08$, $\eta^2 = .06$. No other contrast was statistically significant ($F < 1$).

Discussion

Results from Experiment 6 further corroborate our assumption that automatization of negations is due to instance learning, rather than to an automatization of the general procedure to negate. In the present study, evaluative judgments were qualitatively unaffected by the frequency of negations. For both frequent and rare negations, negated negative words were evaluated more positively than

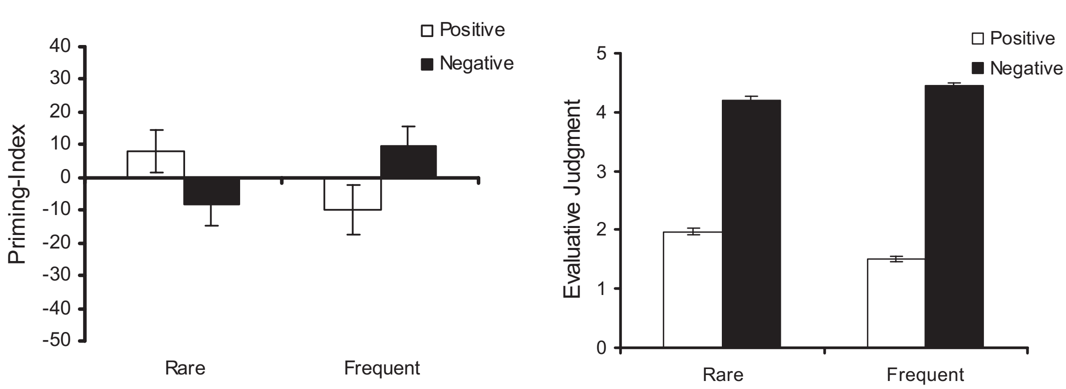

Figure 7. Mean evaluative priming (left) and evaluative judgment effects (right) as a function of word valence and frequency of the negation (Experiment 6). Higher values indicate more positive valence. Note that all stimuli were presented in negated form. Error bars indicate standard errors of the mean.

negated positive words. However, this pattern of results was different for evaluative priming effects. For rare negations, the qualifier did not alter the word valence, such that negated positive words showed a more positive valence than negated negative words. For frequent negations, however, the qualifier did indeed alter word valence, such that negated positive words showed a less positive valence than negated negative words. These findings, together with the results of Experiments 4 and 5, indicate that with extended practice, the cognitive skill of evaluating negated expressions can become very efficient and independent of intentions. This automatic skill, however, is not due to enhanced efficiency of the procedure of negating valence. Rather, our data suggest that the automatic skill is based on the retrieval of highly practiced instances from memory. Notwithstanding these findings, however, it is important to note that we did not manipulate the frequency of negations experimentally; rather, it was based on a pretest. Thus, participants in the pretest could have based their judgments of frequency on the perceived ease with which the meaning of the negation can be extracted. Importantly, ease of extracting the meaning of the negation could be influenced by factors other than frequency. As such, the conclusions drawn from Experiment 6 should be treated as preliminary. Future research should further establish their validity.

General Discussion

The goal of the present research was to investigate the cognitive mechanisms underlying automatic and controlled social–cognitive skills. On the basis of theories of automatization (e.g., Logan, 1988) and dual-systems models in social psychology (e.g., Lieberman et al., 2002; E. R. Smith & DeCoster, 2000; Strack & Deutsch, 2004), we argued that, if a social–cognitive skill becomes automatic through practice, the increased efficiency is caused by a shift from rule-based to association-based processing during automatization. At the same time, however, genuine control processes remain unaffected by practice. More specifically, we claimed that the skill to evaluate affirmed and negated expressions consists of a memory-based, associative component (i.e., the activation of word valence) and a reflective, rule-based component (i.e., the reversal of the retrieved valence in the case of a negated word). We predicted that practicing this skill would increase only the efficiency of the retrieval, not the efficiency of reversing the word's valence. This prediction is supported by the findings of Experiments 1 and 2. Practicing to evaluate affirmed and negated words resulted in a speedup of responses in general. At the same time, however, the difference in response latencies to affirmed and negated words remained constant. Given that responses to affirmed and negated words did not differ in any aspect but the negation, the difference in response latencies can be interpreted as an estimate of the time required to apply the negation (Donders, 1969). Taken together, these results suggest that practice effects in the context of negations are primarily based on the enhanced accessibility of correct responses in memory, whereas genuine control processes remain unaffected by practice.

We further hypothesized that the associative, content-based component of the skill to evaluate affirmed and negated words is executed unintentionally, whereas the reflective, rule-based part depends on intention. Experiments 4 and 5 found that negations did not alter evaluative priming effects of positive and negative words. However, the same negations had a strong impact on evaluative judgments. In particular, positive prime words showed greater automatic positivity than negative prime words, irrespective of whether they were affirmed or negated. This finding also proved to be robust against variations in the priming paradigm.

Finally, we argued that associative mechanisms can substitute reflective mechanisms that underlie a social–cognitive skill. This conclusion is supported by the results of Experiments 3 and 6. In Experiment 3, enhanced practice reduced the difference between response latencies to affirmed and negated trials under conditions that facilitate instance learning. We interpret this finding as evidence that participants stored the correct response to a negated expression in memory. This interpretation is confirmed by the results of Experiment 6, which investigated evaluative priming effects for frequent and rare negations. In this study, frequently negated negative words exhibited a more positive automatic valence than frequently negated positive words. However, evaluative priming effects of rarely negated words exclusively depend on their valence, irrespective of whether these words were affirmed or negated. This result corroborates our assumption that the cognitive skill to negate valence can be performed automatically only under specific conditions, namely when specific instances are stored in associative memory.

Implications for Research on Training Effects

The present results qualify the conclusions commonly drawn from previous research on how social–cognitive skills are affected by practice (e.g., E. R. Smith, 1989; E. R. Smith et al., 1988; E. R. Smith & Lerner, 1986; Rüter & Mussweiler, 2004). Particularly, some researchers argued that practice not only establishes memory-based automaticity, but also makes general rules or procedures more efficient. Our findings suggest, however, that at least some general procedures are not or only very little affected by practice. One potential reason for the diverging results lies in the different methods used to estimate procedure-based and memory-based components of the cognitive skill. Whereas previous research relied on the degree of generalization to new instances to estimate rule-based components, we additionally estimated these components from differences between response latencies to affirmed and negated trials. As outlined above, the degree of generalization can be an ambiguous indicator if there is semantic overlap between training and transfer materials. Our method of estimating the procedural component of negating valence excluded such semantic overlaps. In our studies, the abstract procedure of negating valence was repeatedly applied to a limited set of words, and performance on this negation task was compared with participants' performance on a conceptually corresponding affirmation task. Because responses to affirmed and negated trials should be equally affected by the accessibility of the respective concepts as well as by potential semantic overlaps, these two factors can be ruled out as alternative explanations in the present studies.

It is important to note, however, that we found some evidence for generalization in Experiment 2. In this study, participants' performance with new words was slightly improved as compared with their performance without training. On the surface, these results seem to suggest that the procedure to negate has become more efficient independent of the specific content. Our analysis of the difference in response latencies, however, indicates that this was not the case. In fact, the time necessary to reverse the word valence was the same as in the beginning of the training. If the procedure of negating valence had indeed become quicker, generalization effects should have been larger for negated than for affirmed trials. This, however, was not the case. We therefore conclude that the generalization effects obtained in our study were due to the training of valence-response key mapping, rather than to enhanced efficiency in the procedure of negating valence. There is, however, another possible cause of the fact that we found no indication of rule strengthening while other researchers did. Particularly, it is conceivable that some general procedures are less susceptible to training effects than other procedures. For instance, we consider it possible that the procedure of generating trait-to-behavior inferences (e.g., E. R. Smith et al., 1988) can be automatized, whereas negating cannot. Our theoretical analysis suggests that no or little improvements through training can be expected for those parts of a skill which require genuine control functions, such as action planning, overriding of unwanted habits, and the flexible maintenance and integration of multimodal information (Miller & Cohen, 2001; Hummel & Holyoak, 2003). These control functions are presumably part of a number of social–cognitive processes, such as stereotype-control, social comparisons, complex attributions, but also motivated behavior and problem solving. To the degree that cognitive negations are representative of genuine control functions, one can expect the present results to be informative about how other social–cognitive skills respond to practice. We assume that negations are a good model for flexible, symbol-based processing but that the inference on other control functions like impulse-control or planning is less certain. Clearly, future research will be needed to further bolster such inferences.

Implications for Research on Automaticity

The present results also have important implications for research on automaticity in social psychology. This is particularly the case for studies on complex social–cognitive skills, such as motivated behavior (Bargh & Barndollar, 1996) or problem solving (Dijksterhuis, 2004). In these studies, the respective skills most likely involve a conglomerate of both controlled components (e.g., symbolic representations, flexible response selection) as well as memory-based components (e.g., retrieval of semantic contents from memory). Thus, it is possible that automatic variants of complex social–cognitive skills are partially based on different representations and computations from their controlled variants. Take, for instance, the case in which the same goal is pursued repeatedly in the same situation. In the beginning, genuine control processes may have governed the behavior, compiling new sequences of behavior using abstract symbolic representations. With extended practice, new associative structures in memory may emerge, linking perceptual and motor representations. However, these new associative structures will not be able to circumvent obstacles, which may unexpectedly inhibit successful goal pursuit. In such cases, controlled processes would have to be set in motion to fulfill this function (see Lieberman et al., 2002). Drawing on these considerations, it seems desirable to directly investigate the underlying representations and processes when studying automatic processes in social cognition. The main challenge in this endeavor is to find reliable methods that can distinguish between abstract procedures and associative look-alikes (e.g., Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005).

So far, there are only a few attempts to make similar distinctions in the realm of goal pursuit or other complex skills (see Chartrand & Bargh, 2002). For instance, Bargh, Gollwitzer, Lee-Chai, Barndollar, and Troetschel (2001) specified features specific to controlled goal pursuit, such as an increase of goal strength over time, persistence in the face of obstacles, and the resumption of goal pursuit after interruption. In a series of studies, they demonstrated that these features were also observable if goals were primed instead of conveyed by instructions. Whereas Bargh et al.'s (2001) study suggested that automatic and controlled goal pursuit are mediated by the same mechanisms, a recent study by Dijksterhuis (2004) suggested that unconscious thinking has very different qualities from conscious thought. Particularly, when confronted with complex decision problems, participants made better decisions if they were distracted from engaging in conscious thought than when they were not being distracted. The author concluded that unconscious thought leads to clearer, more polarized, and more integrated representations in memory. What might be the reasons for such diverging evidence to occur? We argue that studies on preexisting skills will often be inconclusive regarding the representations and computations underlying these skills. Associative, content-based simulations of control processes can be very powerful, but they may nevertheless lack important qualities of the controlled process, such as flexibility and generality. Moreover, even if typical features of control are observed with preexisting skills, it could well be the case that the participants are responding based on a differentiated associative structure. As such, it seems desirable to develop training paradigms that can supplement experiments based on preexisting skills.

Implications for Social–Cognitive Phenomena

The present findings also provide a new perspective on previous research automatic stereotype activation. Kawakami et al. (2000), for example, demonstrated that long-term training in the negation of social stereotypes can reduce the subsequent activation of these stereotypes. From a general perspective, these findings could be due to either (a) an improvement of the general procedure to inhibit automatic stereotypes or (b) a storage of negated instances in associative memory. Even though Kawakami et al.'s (2000) data are ambiguous with regard to these explanations, our findings clearly support the latter account. However, they are inconsistent with the former explanation. Specifically, the present results suggest that negation training should lead to a reduction in automatic stereotype activation only if the trained instances are stored in associative memory. Most important, this mechanism implies that negation training for a specific stereotype should not generalize to other stereotypes (unless these stereotypes are semantically related). For instance, enhanced practice in the negation of gender stereotypes may lead to a reduction in the automatic activation of gender stereotypical associations. However, the same training should leave the automatic activation of stereotypes about Black people unaffected.

Similar considerations apply to several other social–cognitive phenomena that involve an important role of negations. With regard to persuasion, for example, one could argue that persuasive attempts containing negated terms may lead to unintended attitude changes in the opposite direction (e.g., Christie et al., 2001; Jung Grant et al., 2004; Skurnik et al., 2005), unless the negated proposition is stored as an independent instance in memory. The same argument could be made for behavior-to-trait inferences, such that perceivers may readily infer the absence of traits from behaviors when the absence of a given trait (e.g., not friendly) is stored as an independent unit in memory (e.g., Hasson et al., 2005; Mayo et al., 2004). Similar conclusions can be drawn for many other social–cognitive phenomena that involve negations, such as innuendo effects (Wegner et al., 1981), attitude change (Petty et al., 2006), perseverance effects (C. A. Anderson, 1982; Walster et al., 1967; Wyer & Unverzagt, 1985), or counterfactual thinking (Roese, 1994). The crucial aspect in all these applications is that negations may lead to ironic or unintended effects, unless the meaning of a negated proposition is stored independently in associative memory.

Conclusion

The main goal of the present research was to investigate whether automatic social–cognitive skills are based on the same representations and processes as their controlled counterparts. Specifically, our experiments were designed to estimate the relative contributions of associative, content-based, and procedural, rule-based components in the processing of negations. Our findings suggest that the procedural, rule-based component of negations is unaffected by increased practice, whereas the associative, content-based component is strongly influenced by training. Generally, these results suggest that practice-related skill improvements are limited to conditions in which a general procedure can be substituted by storing the results of previous applications in associative memory. With extended practice, associative substitutes can be very powerful, and only few experimental paradigms may be able to distinguish them from their controlled counterparts. Although such an analysis is highly feasible within the negation paradigm, it might be harder to do for other social–cognitive skills, such as person perception, goal pursuit, or social comparison. Yet, we conceive this endeavor as the next important step in research on automatic social cognition.

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(*Appendixes follow*)

Appendix A

Stimuli Used in Experiments 1–3

Stimuli were selected on the basis of subjective ratings of valence and frequency of the negated compounds.

Affirmed Positive

EIN TRIUMPH (a triumph), *EIN KINO* (a cinema), *EIN PARADIES* (a paradise), *EINE KARRIERE* (a career), *EIN TANZ* (a dance), *EIN VORBILD* (a role model), *EIN SIEG* (a victory), *EIN WACHSTUM* (a growth), *EIN GENUSS* (a pleasure), *EIN KUCHEN* (a cake)

Affirmed Negative

EIN EITER (a pus), *EINE GESCHWULST* (a tumor), *EIN DIEB* (a thief), *EIN SCHLEIM* (a phlegm), *EINE KAKERLAKE* (a cockroach), *EIN DIKTATOR* (a dictator), *EINE FOLTER* (a torture), *EINE NEUROSE* (a neurosis), *EINE KÜNDIGUNG* (a layoff), *EINE SCHLANGE* (a snake)

Negated Positive

KEIN TRIUMPH (no triumph), *KEIN KINO* (no cinema), *KEIN PARADIES* (no paradise), *KEINE KARRIERE* (no career), *KEIN TANZ* (no dance), *KEIN VORBILD* (no role model), *KEIN SIEG* (no victory), *KEIN WACHSTUM* (no growth), *KEIN GENUSS* (no pleasure), *KEIN KUCHEN* (no cake)

Negated Negative

KEIN EITER (no pus), *KEINE GESCHWULST* (no tumor), *KEIN DIEB* (no thief), *KEIN SCHLEIM* (no phlegm), *KEINE KAKERLAKE* (no cockroach), *KEIN DIKTATOR* (no dictator), *KEINE FOLTER* (no torture), *KEINE NEUROSE* (no neurosis), *KEINE KÜNDIGUNG* (no layoff), *KEINE SCHLANGE* (no snake)

Appendix B

Pretest Data for Negations Used in Experiments 1–3

	Negated positive		Negated negative	
Statistic	Valence	Frequency	Valence	Frequency
M	2.64	3.63	5.31	2.93
SD	0.25	0.57	1.08	1.36

Note. Data represent subjective ratings of valence and frequency in everyday language ($N = 71$). Scales ranged from 1 (*very negative, rare*) to 7 (*very positive, frequent*).

Appendix C

Positive and Negative Words Used in the Practice Trials of Experiment 3

Positive

FREUND (friend), *URLAUB* (vacation), *SOMMER* (summer), *MUSIK* (music), *PARTY* (party), *BLUMEN* (flowers), *GESCHENK* (present), *KINO* (cinema), *ERDBEERE* (strawberry), *PIZZA* (pizza)

Negative

KRIEG (war), *BOMBEN* (bombs), *HASS* (hate), *VIRUS* (virus), *HÖLLE* (hell), *TOD* (death), *KREBS* (cancer), *GEWEHRE* (rifles), *ABFALL* (waste), *MOSKITO* (mosquito)

Appendix D

Prime Stimuli Presented in Experiments 4–5

Affirmed Positive

EIN VERGNÜGEN (an amusement), *EIN FREUND* (a friend), *EIN URLAUB* (a vacation), *EIN SOMMER* (a summer), *EINE PARTY* (a party), *EINE BLUME* (a flower), *EIN GESCHENK* (a present), *EIN GENUSS* (a pleasure), *EINE SCHOKOLADE* (a chocolate), *EIN KUCHEN* (a cake)

Affirmed Negative

EINE BOMBE (a bomb), *EINE KRANKHEIT* (a disease), *EINE BEERDIGUNG* (a funeral) *EIN VIRUS* (a virus), *EIN VERBRECHEN* (a crime), *EINE REZESSION* (a recession), *EINE KAKERLAKE* (a cockroach), *EIN MOSKITO* (a mosquito), *EINE RATTE* (a rat), *EIN WURM* (a worm)

Negated Positive

KEIN VERGNÜGEN (no amusement), *KEIN FREUND* (no friend), *KEIN URLAUB* (no vacation), *KEIN SOMMER* (no summer), *KEINE PARTY* (no party), *KEINE BLUME* (no flower), *KEIN GESCHENK* (no present), *KEIN GENUSS* (no pleasure), *KEINE SCHOKOLADE* (no chocolate), *KEIN KUCHEN* (no cake)

Negated Negative

KEINE BOMBE (no bomb), *KEINE KRANKHEIT* (no disease), *KEINE BEERDIGUNG* (no funeral), *KEIN VIRUS* (no virus), *KEIN VERBRECHEN* (no crime), *KEINE REZESSION* (no recession), *KEINE KAKERLAKE* (no cockroach), *KEIN MOSKITO* (no mosquito), *KEINE RATTE* (no rat), *KEIN WURM* (no worm)

Appendix E

Target Stimuli Presented in Experiments 4–5

Positive Targets

SONNENSCHEIN (sunshine), *MUSIK* (music), *KINO* (cinema), *ERDBEERE* (strawberry), *HAWAII* (Hawaii), *BABY* (baby), *EISCREME* (ice-cream), *SCHWIMMEN* (to swim), *KÄTZCHEN* (kitten), *TANZ* (dance)

Negative Targets

KRIEG (war), *ALKOHOLISMUS* (alcoholism), *ZAHNSCHMERZ* (tooth pain), *HASS* (hate), *HITLER* (Hitler), *HÖLLE* (hell), *SCHEIDUNG* (divorce), *KREBS* (cancer), *MÜLL* (garbage), *ABFALL* (waste)

Appendix F

Prime Stimuli Presented in Experiment 6

Frequent Negated Positive

KEINE LUST (no lust), *KEIN GELD* (no money), *KEINE CHANCE* (no chance), *KEINE SONNE* (no sun), *KEIN GLÜCK* (no luck), *KEINE AUSDAUER* (no endurance), *KEIN SPASS* (no fun), *KEIN VERTRAUEN* (no trust), *KEIN FRIEDEN* (no peace), *KEIN ERFOLG* (no success)

Frequent Negated Negative

KEIN PROBLEM (no problem), *KEINE ANGST* (no fear), *KEINE PANIK* (no panic), *KEINE SORGE* (no sorrow), *KEIN STRESS* (no stress), *KEINE EILE* (no rush), *KEIN KRIEG* (no war), *KEINE GEWALT* (no violence), *KEINE GEBÜHR* (no fee), *KEIN PICKEL* (no pimple)

Rare Negated Positive

KEIN TRIUMPH (no triumph), *KEIN KINO* (no cinema), *KEIN PARADIES* (no paradise), *KEINE KARRIERE* (no career), *KEIN TANZ* (no dance), *KEIN VORBILD* (no role model), *KEIN SIEG* (no victory), *KEIN WACHSTUM* (no growth), *KEIN GENUSS* (no pleasure), *KEIN KUCHEN* (no cake)

Rare Negated Negative

KEIN EITER (no pus), *KEINE GESCHWULST* (no tumor), *KEIN DIEB* (no thief), *KEIN SCHLEIM* (no phlegm), *KEINE KAKERLAKE* (no cockroach), *KEIN DIKTATOR* (no dictator), *KEINE FOLTER* (no torture), *KEINE NEUROSE* (no neurosis), *KEINE KÜNDIGUNG* (no layoff), *KEINE SCHLANGE* (no snake)

Appendix G

Target Stimuli Presented in Experiment 6

Positive Targets

GESCHENK (gift), *MUSIK* (music), *PARTY* (party), *ERDBEERE* (strawberry), *HAWAII* (Hawaii), *BABY* (baby), *EISCREME* (ice cream), *URLAUB* (vacation), *KÄTZCHEN* (kitten), *BLUMEN* (flowers)

Negative Targets

HITLER (Hitler), *BOMBEN* (bombs), *ALKOHOLISMUS* (alcoholism), *ZAHNSCHMERZ* (tooth pain), *HASS* (hate), *HÖLLE* (hell), *SCHEIDUNG* (divorce), *KREBS* (cancer), *MÜLL* (garbage), *ABFALL* (waste)

Appendix H

Pretest Data for Frequent and Rare Negations Used in Experiment 6

Frequency category	Negated positive		Negated negative	
	Valence	Frequency	Valence	Frequency
Frequent				
M	1.94	5.86	6.19	5.77
SD	0.32	0.44	0.38	0.40
Rare				
M	2.64	3.63	5.31	2.93
SD	0.25	0.57	1.08	1.36

Note. Data represent subjective ratings of valence and frequency in everyday language ($N = 71$). Scales ranged from 1 (*very negative, rare*) to 7 (*very positive, frequent*).

Received May 1, 2005
Revision received November 3, 2005
Accepted November 29, 2005 ■