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Sequential Priming Measures of Implicit Social Cognition: A Meta-Analysis of Associations With Behavior and Explicit Attitudes

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Abstract

In a comprehensive meta-analysis of 167 studies, the authors found that sequential priming tasks were significantly associated with behavioral measures ($r = .28$) and with explicit attitude measures ($r = .20$). Priming tasks continued to predict behavior after controlling for the effects of explicit attitudes. These results generalized across a variety of study domains and methodological variations. Within-study moderator analyses revealed that priming tasks have good specificity, only predicting behavior and explicit measures under theoretically expected conditions. Together, these results indicate that sequential priming—one of the earliest methods of investigating implicit social cognition—continues to be a valid tool for the psychological scientist.

Keywords

automatic/implicit processes, social cognition, prejudice/stereotyping, individual differences, attitudes

Behavioral scientists have designed ingenious methods for measuring thoughts and behaviors by the traces they leave behind. Advertising effectiveness, for example, has been measured by the number of smudges left on the pages of periodicals (DuBois, 1963). The relative preoccupation of men and women with erotica was estimated by the frequency of erotic graffiti in men's versus women's bathrooms (Kinsey, Pomeroy, Martin, & Gebhard, 1953). Alcohol consumption in a town with no liquor stores was measured by counting empty liquor bottles hauled away in the town's refuse (Sawyer, 1961; for a review of early approaches to indirect measurement, see Webb, Campbell, Schwartz, & Sechrest, 1966). Indirect measures such as these are useful in any situation where self-reports are of doubtful validity.

As with graffiti and alcohol consumption, one critical reason for using indirect measures is social desirability. Research participants attempting to present themselves in a favorable light may report strategically rather than candidly, and indirect measures help overcome this problem. Social desirability, however, is not the only reason psychologists turn to indirect measures. In some cases, participants may not be able to provide valid self-reports because the processes of interest are invisible to introspection. In the 1980s and 1990s, researchers transformed indirect measures into implicit measures by devising clever ways to assess unconscious and automatic thought processes.

These measures developed in tandem with dual-process theories in social psychology, which emphasized the distinction between automatic processes—fast, effortless, unintentional, and in some cases unconscious—and controlled processes, which are slower, effortful, and consciously controlled (Chaiken & Trope, 1999; Strack & Deutsch, 2004). Implicit measures served two purposes at once. Like other indirect tests, they circumvented self-report biases. In addition, they provided an opportunity to measure mental content that was activated automatically or implicitly. Sequential priming is one of the most widely used methods for measuring implicit social cognition.

Priming involves presenting some stimulus with the aim of activating a particular idea, category, or feeling and then measuring the effects of the prime on performance in some other task. Because the human mind is organized as networks of associations, activating any one idea has the effect of spontaneously drawing to mind associated thoughts, memories, and feelings. Priming can be used as a means of mapping the networks of associations for an individual because the same primes tend to activate different associative links for different people. The name of the U.S. president, for example, may activate very different ideas in the minds of

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Democrats and Republicans. The face of a Black man may activate different feelings for individuals high versus low in prejudice. A prime of a burning cigarette may ignite craving for smokers but revulsion for nonsmokers. Priming, thus, allows researchers to measure what associations are automatically activated for a given person in response to a particular stimulus.

Priming techniques were among the earliest developed methods for studying implicit social cognition. Building on earlier semantic priming studies (e.g., Meyer & Schvaneveldt, 1971; Neely, 1977), researchers used sequential priming to investigate stereotype and attitude associations without relying on self-reports (Dovidio, Evans, & Tyler, 1986; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Gaertner & McLaughlin, 1983). The use of sequential priming tasks as individual difference measures was accelerated, however, when Fazio and colleagues (1995) adapted sequential priming to measure individual differences in racial attitudes. In this procedure, faces of Black and White individuals were presented as primes, followed by pleasant and unpleasant words as targets to be evaluated. Subjects responded by evaluating the words as good or bad, and their response times served as the dependent variable. Priming was measured as the extent to which the race of the primes facilitated the evaluation of the target words.

Fazio and colleagues (1995) reported that individual differences in priming were associated with uncomfortable behavior toward an African American interaction partner. Moreover, priming scores were associated with explicitly measured prejudice, but only among subjects who were not motivated to control the expression of prejudice. This demonstrated that priming methods could be used as valid predictors of behavior in a domain where people were often motivated to carefully control the overt expression of attitudes. These early papers set the stage for the rapidly growing field of implicit social cognition by measuring associations that spring automatically to mind for a given individual.

Despite the early excitement over these methods, priming tasks had psychometric limitations. Most critically, priming measures suffered from low reliability (Bosson, Swann, & Pennebaker, 2000; Fazio & Olson, 2003). This is one reason that many researchers have employed the implicit association test rather than priming to measure individual differences in implicit social cognition (Implicit Association Test [IAT]; Greenwald, McGhee, & Schwartz, 1998). The IAT, however, has been controversial for other reasons. Because of its complex dual task structure, participants may adopt a variety of strategies to pair the two sets of items. The way participants construe the pairings may affect the constructs that are measured. Researchers have critiqued the IAT on grounds that in addition to attitudes, it may reflect other constructs such as cultural knowledge (Karpinski & Hilton, 2001; Olson & Fazio, 2004), similarity between concepts (De Houwer, Geldof, & De Bruycker, 2005), or salience differences between the two sets of items that are paired (Rothermund & Wentura, 2004). Despite controversy over the interpretation of IAT scores (Blanton & Jaccard, 2006), the IAT has often been the implicit measure of choice because of its relatively high reliability.

Recent innovations, however, have improved reliability for some priming tasks. One change was to shift from measuring reaction times to measuring accuracy. When subjects are required to respond quickly, priming effects can be measured as differential error rates rather than facilitation of response times (Draine & Greenwald, 1998; Musch & Klauer, 2001; Payne, 2001). Accuracy-based measures have sometimes displayed higher reliability than measures based on response times (e.g., Payne, 2005). A second change was to shift from response times to evaluations of ambiguous stimuli (Murphy & Zajonc, 1993; Payne, Cheng, Govorun, & Stewart, 2005). The affect misattribution procedure (AMP) presents pleasant and unpleasant photos as primes, followed by Chinese writing symbols. Subjects decide whether each symbol is relatively pleasant or unpleasant. Priming is measured as the influence of the prime valence on the frequency of pleasant judgments. Priming scores in the AMP have proven highly reliable. Shifting to accuracy and evaluative ratings has increased the reliability of sequential priming tasks, and these measures are now in common use alongside reaction time-based measures.

The simplicity of priming tasks, together with recent improvements in reliability, suggests that they are a valuable set of tools for studying implicit social cognition. Although many studies have used priming measures, there have been no quantitative reviews of sequential priming tasks, and no systematic comparison of the factors affecting their validity. We aim to provide a comprehensive meta-analytic review by examining the relationship of priming tasks to explicit measures and to behavior. We will consider which types of tasks, what procedural factors, and what theoretically predicted moderators contribute to valid measurement.

Theoretical Framework

We derived our moderators from prominent dual-process models of social cognition. We consider the Motivation and Opportunity as Determinants (MODE) model (Fazio, 1990), the Associative-Propositional Evaluation model (Gawronski & Bodenhausen, 2006), and the Meta-cognitive model (Petty, Briñol, & DeMarree, 2007). Although each of these models differs in the particular processes emphasized, they share a common set of assumptions about the importance of automatic and controlled processes. Moreover, they converge on some basic predictions about the factors that should moderate the ability of implicit tests to predict behaviors and explicit judgments, as will be seen in the following.

An early and influential dual-process model was the (MODE model; Fazio, 1990). According to this model,

automatically activated attitudes reflect object-evaluation associations that are elicited spontaneously and inescapably in response to attitude objects. Sequential priming tasks have often been used to assess such automatic evaluations. By contrast, explicit attitude measures capture these attitudes "downstream" after people have had the chance to correct them for accuracy or self-presentational reasons. When people do not deliberate, implicit and explicit responses are driven by automatic evaluations. However, when they deliberate, they are likely to adjust explicit but not implicit responses. Thus, from the perspective of the MODE model, sequential priming should better predict explicit attitudes and behavior when there is little motivation or opportunity to deliberate on attitude self-reports or behavioral responses.

The Associative-Propositional Evaluation model (Gawronski & Bodenhausen, 2006) distinguishes associative processing—which involves spreading activation among associative links—and propositional processing, which involves assessing truth values of propositions. Implicit tests have been considered a proxy for associative processes, whereas explicit measures have been used to capture the outcome of propositional processes. According to the model, automatically activated associations are treated as valid by default. When cognitive resources are available, however, people can consider additional information that might conflict with propositions derived from automatic associations. Greater elaboration need not lead to divergence if it does not create inconsistency with automatic associations. However, people are most likely to engage in elaborate propositional reasoning when they detect some conflict between activated associations and other beliefs or values that they hold. All else being equal, this will tend to lead to lower implicit–explicit correspondence under conditions of high deliberation. Thus, like the MODE model, this model predicts that sequential priming will predict explicit attitudes and behavior most strongly when people are unable or unmotivated to engage in cognitive elaboration that might invalidate automatic associations.

Finally, the meta-cognitive model posits that people can label their object-evaluation associations as true or false—based on consistency and confidence—and then store these meta-cognitive validity tags in memory (Petty et al., 2007). Sequential priming tasks capture automatic associations unmodified by validity tags, because these tags take more time and effort to retrieve. Explicit measures, in contrast, reflect evaluative associations and the validation or rejection of those associations. Like the other two models reviewed, the meta-cognitive model predicts that sequential priming will predict explicit attitudes and behavior most strongly when people lack the motivation or ability to access or consider validity tags.

As this brief review makes clear, even though different dual-process models emphasize different cognitive processes (e.g., activation of evaluations vs. correction of judgments and behavior; associations vs. propositional reasoning; activation of evaluations vs. retrieval of validity tags), they have similar implications for many of the factors that might moderate effects of implicit attitudes. Although the models differ in their characterizations of why this should be the case, they provide enough of a consensus to derive a common set of predictions about critical moderators that may be used to organize the literature. The models converge in predicting that sequential priming tasks will correspond more strongly with explicit attitudes and behaviors when there is lower motivation and/or opportunity to engage in deliberative processing, or when the implications of automatic associations and deliberately considered propositions are consistent with each other.

The theoretical moderators we tested are not aimed at testing one dual-process model against others. Instead, the aim is to examine whether the literature supports the broader claims that most dual-process models have in common. By doing so, we aim to evaluate how well the empirical evidence supports the dual-process theorizing that has motivated most of the research on implicit social cognition.

Questions Addressed by the Meta-Analysis

The present review addresses four primary questions. First, what is the relationship between priming tasks and measures of behavior? Second, what is the relationship between priming tasks and measures of explicit attitudes or other relevant constructs? (The explicit measures included in the analysis are primarily attitude measures, although other constructs such as stereotypes and traits are also included. For simplicity we use the phrase *explicit attitudes* to refer to this collection of explicitly measured constructs.) In some cases, researchers examine results of implicit tests in conditions where they are predicted *not* to have significant effects. Our third question therefore concerns whether priming tasks show specificity: Are priming tasks related to other measures selectively under theoretically predicted conditions? We examined within-study and between-study moderators to answer this question. Fourth, what methodological recommendations can be gleaned to maximize the validity of priming tasks?

Method

Criteria for Study Inclusion

Studies were included if they met two criteria. First, they had to utilize a sequential priming task to measure individual differences in beliefs or attitudes. We considered as relevant the evaluative priming task (Fazio et al., 1986), the AMP (Payne et al., 2005), the weapon identification task (Payne, 2001), and the lexical decision task (Meyer & Schvaneveldt, 1971) and related semantic priming tasks (e.g., Banaji & Hardin, 1996). We also included the Eriksen flanker task

(Eriksen & Eriksen, 1974) and the shooter task (Correll, Park, Judd, & Wittenbrink, 2002), which present the "prime" and "target" stimuli simultaneously. We considered these to be equivalent to sequential priming tasks in which the stimulus onset asynchrony (SOA) between prime and target (a variable analyzed in the meta-analysis) is zero. The second criterion was that the study examined the relationship between the sequential priming measure and one of the two outcomes: behaviors (including behavioral intentions and judgments) or explicit measures of the same construct (e.g., explicit attitudes, beliefs, or trait ascriptions). Although there are many studies examining how automatic or subliminal activation of stereotypes can influence subsequent judgments (e.g., Chen & Bargh, 1997; Devine, 1989), these do not treat sequential priming performance as an individual difference that can then be related to explicit attitudes or behaviors. Studies were also not included if they only examined the relationship between a sequential priming measure and another implicit measure (e.g., the IAT). For studies that did not provide adequate statistical information for the derivation of an effect size, we contacted authors for more information.

Search Method

Studies were identified using two methods. First, we conducted searches in PsycINFO and Google Scholar using the following keywords: *affective priming* and *behavior, evaluative priming* and *behavior, semantic priming* and *behavior, affective priming, evaluative priming, semantic priming*, and *lexical decision task.* Further articles were obtained from the references section of these articles, as well as from prominent narrative reviews of implicit social cognition effects (Fazio & Olson, 2003; Friese, Hofmann, & Schmitt, 2008; Gawronski, Hofmann, & Wilbur, 2006; Wentura & Degner, 2010). Second, we sent an email to the Society for Personality and Social Psychology mailing list, requesting any in press or unpublished manuscripts that met our inclusion criteria. After this initial search, we excluded articles that reviewed sequential priming findings without presenting any original data. We also excluded studies that did not look at the relationship between sequential priming and either behaviors or explicit attitudes; that utilized implicit measures other than sequential priming (such as the IAT, Go/No-Go Association Task, or Extrinsic Affective Simon Task); and that used goal or construct priming rather than individual difference measures of sequential priming. After making these exclusions, we were left with a list of 191 independent studies for possible inclusion in the meta-analysis. From this list of studies, we excluded studies that did not report statistical information that could be converted into effect sizes ($n = 5$), and that did not correlate sequential priming with a criterion measure that we could reasonably determine as attitudinal or behavioral ($n = 20$).

In total, we gathered 167 independent studies that met our inclusion criteria. Of these, 86 studies reported a relationship between a sequential priming measure and behavior, and 116 reported a relationship between a sequential priming measure and attitudes. Thirty-four of the studies reported correlations of priming measures with attitude and behavior criterion measures.

Description and Coding of Moderators

Two researchers coded each study independently, using a coding manual devised collaboratively by the three authors. For discrete variables, disagreements between the two coders were resolved by a third coder. For continuous variables, the coders' ratings were averaged. Interrater reliability for continuous ratings was assessed using the intraclass correlation coefficient and is reported along with the descriptions of individual variables below.

Within-Study Theoretical Moderators. We coded each study for whether it included a within-study moderator and reported sufficient statistics to derive an effect size at each level of the moderator. For each of these samples, we computed the effect sizes separately for conditions in which the priming task was predicted by the authors of the original paper to show a significant association with another variable, and those conditions in which it was expected to show no association. For the behavior meta-analysis, 18 studies reported within-study moderators. For the attitudes meta-analysis, 22 studies reported within-study moderators. Details and citations for these within-study moderators are provided in Table 1.

A concern about the foregoing analyses is that there is no independent criterion for predicting whether or not implicit attitudes will predict attitudes or behavior, other than the arguments provided in the original articles by the authors. Some of the moderators are meaningful for a particular topic or sample, but may not apply broadly. In light of this concern, we also conducted more focused analyses of studies, including within-study moderators derived from dual-process theories of social cognition. These dual-process moderators could be derived a priori from the theoretical literature, without recourse to the specifics of any given sample or domain of study. Two coders classified whether each moderator could be derived from the central claims of the dual-process theories reviewed above and whether each factor should be expected to increase or decrease correspondence between priming and outcome measures. Within-study moderators that fall into this subcategory are indicated in Table 1.

Between-Study Theoretical Moderators. According to dual-process theories, sequential priming tasks should be effective at capturing spontaneous reactions that escape control efforts (Chaiken & Trope, 1999). It might therefore be expected that priming tasks may show stronger relationships

Table 1. Description of Within-Study Moderators

Meta-analysis	Moderating variable	Why it should moderate influence of sequential priming on outcome measure?	Moderator based directly on dual-process theories?	Citation
Behavior	Activation of norm by environmental cues	Situational cues increase relevance of environment-norm associations for behavioral outcomes	No	Aarts and Dijksterhuis (2003)
	Race of Cyberball partner	Implicit anti-Turkish attitudes predict increased Cyberball tossing to unfair Turkish (vs. German) co-player, because of intent to provoke out-group member or justify prejudices	No	Degner, Wentura, Gniewosz, & Noack, (2007)
	Relationship status (Recent break-up vs. still in relationship)	In the break up group, implicit negative attitudes toward old partner serve a coping function and should relate to depressed affect; for those still in relationships, implicit negative attitudes do not serve the same function	No	Fagundes (2011)
	Goal relevance of food options	Implicit positive attitudes toward goals only predict goal-relevant choices, because irrelevant behaviors bear no associative relationship with the goal	No	Ferguson (2007, Study 3)
	Activation of goal	Goal pursuit increases relevance of goal-positivity associations for behavioral outcomes	No	Ferguson (2008, Studies 1-5)
	Preference for intuition	If people trust their immediate emotional reactions, they will rely on them more strongly when making moral decisions.	Yes	Hofmann and Baumert (2010, Studies 1 and 2)
	Perceived out-group variability	If the out-group is perceived to be homogeneous, then individuals feel confident in their implicit attitudes toward outgroups and behave in a consistent manner.	No	Lambert, Payne, Ramsey, and Shaffer (2005, Studies 1 and 2)
	Motivation to control prejudice	People with lower motivation to control prejudice are less concerned about reporting politically correct explicit trait judgments	Yes	Olson and Fazio, 2004
	Social pressure	People who are under less social pressure to conceal drinking behaviors will be less concerned about letting their automatic reactions toward alcohol guide drinking behaviors	Yes	Payne, Govorun, and Arbuckle (2008, Studies 3 and 4)
	Self-relevance of interview	When an interview is self-relevant, self concerns become active and implicit processes will be more likely to leak out into nonverbal behavior	No	Spalding and Hardin (1999)
	Participant gender	Men are less motivated than women to conceal power-sex associations or prevent their influence on behavior	Yes	Zurbriggen (2000)
Attitudes	Social context	Positive social contexts activate new associations that will decrease implicit race bias, making implicit responses more consistent with motivations to control prejudiced reactions	No	Allen, Sherman, and Klauer (2010)
	Nationalism	For people high in nationalism, exposure to American flag activates egalitarian goals which increase correspondence between flag-egalitarianism priming and judgments of outgroups	No	Butz, Plant, and Doerr (2007, Study 3)
	Valence of political campaign	Negative campaign information becomes implicitly associated with both candidates, but does not influence explicit political attitudes about the target of a negative campaign, thus decreasing correspondence between implicit and explicit political preferences for one candidate over another	No	Carraro, Gawronski, and Castelli (2010)
	Direction of attention on evaluative priming task	If attention not directed to category primes on priming task, there is no priming effect and thus no relationship with explicit attitudes	No	Gawronski, Cunningham, LeBel, and Deutsch (2010)

(continued)

Table 1. (continued)

Meta-analysis	Moderating variable	Why it should moderate influence of sequential priming on outcome measure?	Moderator based directly on dual-process theories?	Citation
	Introspection on feelings v. reasons	Introspecting on reasons introduces additional information that reduces the influence of automatic associations on explicit attitudes	Yes	Gawronski and LeBel (2008)
	Motivation to control prejudice	People with lower motivation to control prejudice are less concerned about reporting politically correct explicit attitudes	Yes	Gawronski, Peters, Brochu, and Strack, 2008, Studies 1 and 2)
	Motivation to control prejudice	People with lower motivation to control prejudice are less concerned about reporting politically correct explicit attitudes	Yes	Gawronski and Yeh (unpublished, Study 4)
	Presence of bogus pipeline	The bogus pipeline reduces the motivation to report politically correct explicit attitudes	Yes	Imhoff and Banse (2009)
	Relationship status (found new partner after break-up or not)	After a break-up, implicit positive associations toward old partner persist even if explicit attitudes are negative; finding a new partner decreases implicit positive associations toward old partner and promotes congruence with explicit attitudes	No	Imhoff and Banse (2011)
	Self-deception	Explicit homophobia predicts reduced viewing time of gay stimuli for people with high self-deception because these people are especially defensive against exposure to homosexuality	Yes	Meier, Robinson, Gaither, and Heinert (2006)
	Motivation to control prejudice	People with lower motivation to control prejudice are less concerned about reporting politically correct explicit attitudes	Yes	Payne (2001, Studies 1 and 2)
	Motivation to control prejudice	People with lower motivation to control prejudice are less concerned about reporting politically correct explicit attitudes	Yes	Payne, Cheng, Govorun, and Stewart (2005, Study 6)
	Ownership of implicit attitudes	When people infer that automatic attitudes are their own, they will rely on them when reporting explicit attitudes	Yes	Payne, Cooley, and Lei (unpublished, Studies 1-3)
	Correspondence between attractiveness and ambition of prospective romantic partner	When propositional information about ambition is consistent with attractiveness-related automatic associations, people feel more justified using these associations to form explicit evaluations	Yes	Sritharan, Heilpern, Wilbur, and Gawronski (2010, Studies 1 and 2)
	Congruence between centrality of a trait (high/low) and ability on a skill related to that trait (high/low)	When the importance of a trait to the self-concept matches the perceived ability for a skill related to that trait (either both are high or both are low), then those skills become highly accessible on the sentence priming task, and relate more strongly to the self-reported ability on those traits	No	Wentura and Greve (2005)
	Social context	Positive social contexts activate new associations that diminish implicit racial bias, making the relationship with explicit racial bias less systematic	No	Wittenbrink, Judd, and Park (2001, Study 2)

with behaviors and attitude measures that are less controllable and less socially sensitive.

Controllability of response to the criterion measure. Many dual-process theories posit that implicit measures of attitudes are more likely to predict less controllable behaviors, because such behaviors are less likely to be corrected by impression management strategies. However, implicit measures have also been linked to ostensibly controllable outcomes, such as court sentencing decisions (Eberhardt, Davies, Purdie-Vaughns, & Johnson, 2006). On the other

hand, more controllable, deliberative self-report measures of attitudes might allow for the consideration of additional information that would reduce the influence of implicit attitudes (Gawronski & Bodenhausen, 2006). Criterion measures that allow for greater control might allow for greater impression management. To examine this moderator, we coded criterion measures for the degree to which they were controllable (1 = *responses are not at all controllable* to 5 = *responses are entirely controllable*). Interrater reliability was .82.

Social sensitivity of the criterion measure. Sequential priming measures have been used to explore socially undesirable or inappropriate attitudes that might not ordinarily be expressed in self-reports (e.g., Fazio et al., 1995). Priming measures might not predict socially undesirable or sensitive behaviors or attitudes, because people are motivated to correct for their implicit reactions. We coded each study for the degree to which its criterion measure might activate social sensitivity concerns (1 = *not at all affected by social sensitivity concerns* to 5 = *extremely affected by social sensitivity concerns*). Interrater reliability was .73.

Implicit-explicit attitude correlation. Our search found 34 samples that examined relationships with explicit attitudes and behavior within the same study. Greenwald and colleagues (2009) found that stronger relationships between the IAT and explicit attitude measures predicted stronger relationships between the IAT and behavioral outcomes. They argued that stronger implicit–explicit correlations might indicate less intrapsychic conflict and greater mutual reinforcement between implicit and explicit attitudes. This mutual support might strengthen relationships between implicit measures and behavioral outcomes. We examined whether larger correlations between priming tasks and explicit attitude measures predicted larger correlations between priming tasks and behaviors.

Explicit attitude-behavior correlation. Our search found 38 samples that reported implicit attitude-behavior and explicit attitude-behavior correlations within the same study. To assess the incremental validity of sequential priming measures, we examined whether sequential priming measures would predict behavior even when controlling for the relationship between explicit attitudes and behavior. Such a finding would suggest that sequential priming measures predict behavior independently of explicit attitude measures.

Methodological Moderators. Methodological moderators included features of the priming task and criterion measure, the setting in which the study was conducted, publication status, and year of study publication. All of these were objective variables with the exception of ecological realism, which was coded by two raters.

Number of trials. We coded for number of trials on the sequential priming measure. We included all trials contained within the task that were not practice trials. Because priming tasks with fewer trials risk low reliability and validity (Wentura & Degner, 2010), measures with more trials may show stronger relationships with criterion measures.

Type of prime stimulus. There has been debate over the relative effectiveness of different types of primes (e.g., images vs. words; Wentura & Degner, 2010). We thus coded each study for prime type (*names, images, words, other*). If a study used multiple priming tasks with varying prime types, we took the average effect size (see *calculation of effect sizes* below) and did not code prime type.

Presentation timing. We coded prime duration, target duration, and the time between the initial onsets of the prime and target stimuli (SOA) in milliseconds. We also coded intertrial interval as the time in milliseconds between the offset of a response on a given trial and the beginning of the first prime stimulus on the subsequent trial. In cases where the target remained on screen until a response was entered, we coded target duration as the maximum target duration across samples (behavior = 5,000 ms; attitudes = 2,500 ms). Longer presentation times may allow for greater awareness of and control over prime influence, and have been shown to reduce priming effects (Payne et al., 2005; Payne, Hall, Cameron, & Bishara, 2010; Wentura & Degner, 2010). These longer durations might thus reduce validity. If studies utilized varying levels of any of the foregoing timing parameters, we took the average.

Subliminal presentation. It has been debated whether primes must be presented subliminally on priming tasks to bypass correction efforts (Moors, Spruyt, & De Houwer, 2010). We coded for this moderator to test whether prime consciousness influenced relationships with behaviors and attitudes (0 = *conscious prime presentation,* 1 = *subconscious prime presentation*). We based this coding on whether the study authors considered the prime presentation to be subliminal because we had no independent means of verifying whether items were consciously perceived.

Observation of criterion measures. We coded for whether the behavioral criterion measure was subject-observed *(0)* or experimenter-observed *(1)*. Subject-observed outcomes (e.g., self-reports of past behavior or behavioral intentions) might be more subject to reconstruction biases, which could either increase or decrease the relationship with priming tasks. Because all explicit attitude criterion measures were self-report, we did not code for this moderator in the attitudes meta-analysis.

Ecological realism. We coded for two methodological moderators related to the ecological validity of each sample. First, we coded for whether each study was conducted in a laboratory *(1)* or in a field setting *(0)*. Because lab settings often allow for greater experimental control, it may be easier to detect significant relationships in these contexts. We also coded for the ecological realism of each criterion measure (1 = *not at all ecologically realistic* to 5 = *extremely ecologically realistic*). Interrater reliability was .86.

Publication status. We coded for whether the sample was published in an academic journal *(1)* or not published *(0)*. In the behavior meta-analysis, all of the samples came from

published journal articles. In the attitudes meta-analysis, 91 samples came from published articles and 25 samples came from unpublished sources. Thus, we coded publication status only for the attitudes meta-analysis.

Publication year. Finally, we coded for the year of study publication. Many papers have been published in the last three decades about methodological factors that increase or decrease attitude-behavior correspondence and implicit–explicit correspondence. If the field is making progress toward better measurement procedures, we might expect to see higher levels of validity over time.

Domain of Study. Each study was categorized into one of seven domains: prejudice (including race, gender, and groups), consumer preferences, political preferences, personality traits (including self-esteem and self-concept), impulsive behavior (involving nonclinical levels of tempting behaviors such as eating, drinking, and smoking), clinical psychology (involving studies among clinical populations such as depressed individuals), close relationships, and "other" for samples that did not fit any of the preceding categories.

Type of Priming Task. Each study was also categorized based on the type of sequential priming task utilized: AMP, weapon identification task, shooter task, flanker task, lexical decision task, evaluative priming task, and "other" for sequential priming tasks that did not fit any of these categories.

Calculation of Effect Sizes

Each study that met our criteria for inclusion was separated into independent samples. We converted all effect size estimates (i.e., regression coefficients, Cohen's *d* values, *t* statistics, *F* statistics, Wald statistics, odds ratios) to Pearson correlations. In line with the meta-analysis of the correlation between implicit and explicit measures of attitudes conducted by Hofmann and colleagues (2005), we did not convert correlations to Fisher's *z* scores for further computation, because of the risk of biasing mean correlation estimates upward. We did not correct for attenuation of correlations by measurement error, because with a few notable exceptions, insufficient reliability information was reported for priming tasks. If a study reported correlations between a sequential priming measure and multiple behavior or multiple attitude criterion measures, we averaged across these correlations. Similarly, if a study correlated multiple forms of the same type of sequential priming measure (e.g., slight variants of an evaluative priming task) with a criterion measure, we averaged across these correlations. Thus, for each independent sample we computed a single correlation of interest.

Analytic Model

To examine moderators of the overall effect sizes, we conducted two random effects meta-analyses on behavior and attitudes (Borenstein, Hedges, Higgins, & Rothstein, 2009). In computing the aggregate effect size within each meta-analysis, each sample effect size was assigned a random effects weight based on sample size, between-study variance due to fluctuation around the mean effect size, and within-study variance due to sampling error (Borenstein et al., 2009).

We used analysis of variance models to examine the two multiple-level categorical moderators (study domain and type of priming task). The resulting Q_{Bet} statistic provides a measure of heterogeneity of effect sizes across levels of the moderator. We used a series of weighted meta-regression models to examine the theoretical and methodological moderators. These analyses were conducted as random-intercept, fixed-slope models using maximum likelihood estimation. For a given level of a moderator to be included for analysis, there had to be a minimum of five samples.

Results

Aggregate Effect Sizes

We examined aggregate effect sizes for the relationship between sequential priming measures and behavior and attitude criterion measures, respectively. Random effects meta-analyses produced aggregate weighted effect sizes of $r = .28$ for behavior measures and $r = .20$ for explicit attitude measures (both ps $< .00001$). Priming tasks thus display small to medium sized relationships with relevant behavior and explicit attitude measures.

Among the samples considered here, 38 reported the relationship between explicit attitudes and behavior. The aggregate effect size for explicit attitude measures predicting behavior was $r = .25$. In addition, 28 samples reported all three relationships—priming behavior, priming attitudes, and attitudes behavior—allowing us to examine whether implicit attitudes predicted behavior significantly better than explicit attitudes (Steiger, 1980). The attitude-behavior relationship was not significantly different for implicit versus explicit attitudes, $t(25) = .10$, $p = .92$.

Finally, we examined whether sequential priming measures predicted behaviors while controlling for the relationship between explicit attitudes and behaviors. Results indicated that implicit measures continued to predict behaviors even when controlling for the explicit attitudes-behavior relationship (intercept $B = .29$, $Z = 6.12$, $p < .0001$). Thus, sequential priming measures have incremental predictive validity over explicit attitude measures.

Assessing the Impact of Publication Bias

Most of the studies in our analysis were published studies, which poses the risk that our estimates are inflated by publication bias. Publication bias occurs when papers reporting significant results are more likely to be published than

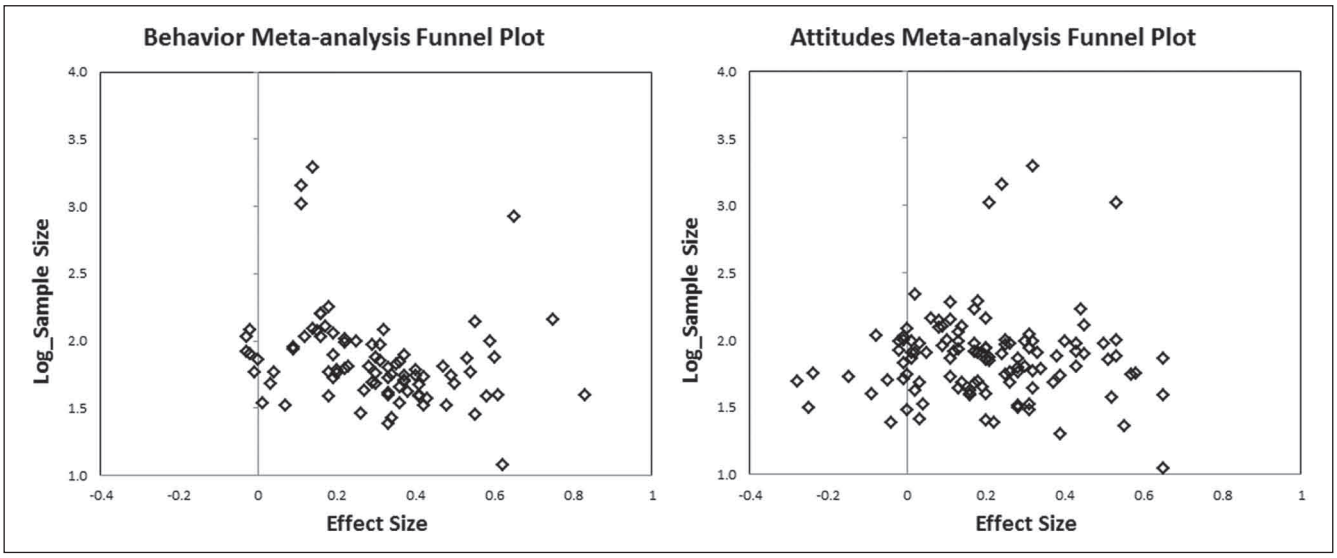

Figure 1. Funnel plots for the priming-behavior and priming-attitude meta-analyses.
Sample size is log-transformed for enhanced visual presentation.

papers reporting null results. The result is a biased selection of studies in which those showing small relationships are systematically excluded. To examine whether publication bias was likely to affect our result we examined a funnel plot, in which we plotted the effect size in each study against the sample size. A publication bias that excludes nonsignificant findings would appear as an absence of small effect sizes in studies with small samples, because only large effects would be significant in small samples. As shown in Figure 1, the results appear symmetrical around the mean effect size estimates, suggesting that the meta-analysis was not influenced by publication bias. To quantify the relationship between effect sizes and sample sizes, we computed the Pearson correlations between the two. The relationship was nonsignificant for behaviors ($r = -.17$, $p = .14$) and for explicit measures ($r = .09$, $p = .32$).

Finally, the attitudes meta-analysis contained enough unpublished studies that we could examine publication status as a moderator of convergent validity. There was no significant difference in the effect size of published versus unpublished studies, $\beta = .01$, $Z = .07$, $p = .94$, $R^2 = .00$. Thus, it appears unlikely that our results are due to publication bias.[1]

Both aggregate effect sizes showed significant heterogeneity, $Q_{Behavior} = 392.28$, $Q_{Attitudes} = 297.30$ (both ps $< .00001$), suggesting substantial between-study variability in predictive and convergent validity. To better understand this variability, we conducted three sets of moderation analyses. First, we explored studies that had within-study moderators to investigate whether relationships between priming and other variables would be stronger when such relationships were theoretically predicted to hold. Second, we explored between-study theoretical moderators. Third, we explored whether validity differed as a function of the domain of study and methodological features of the priming tasks.

Within-Study Theoretical Moderators

We first examined studies that included a within-study moderator and reported effect sizes for the relationship between sequential priming measures and criterion measures at each level of the moderator. For example, Hofmann and Baumert (2010; Studies 1 and 2) predicted that automatic affective reactions toward moral stimuli (assessed via the AMP) would predict moral behaviors only for people high in preference for intuition, because these people would be more likely to rely on immediate affective reactions when making decisions. We conducted these analyses separately for variables predicted for any reason by the original study authors as moderators and for variables coded independently by the meta-analysts as moderators predicted directly by dual-process theories. If sequential priming measures have appropriate specificity and precision, then they should only relate to criterion measures when such a relationship is predicted on the basis of within-study moderators.

Moderators predicted by original study authors. For the 18 studies in the behavior meta-analysis that included within-study moderators, the effect size for the predicted condition was $r = .40$ ($p < .00001$, $Q = 30.10$). However, for the non-predicted condition, the effect size was $r = -.004$ ($p = .99$, $Q = 24.63$). The difference between these aggregate effect sizes was significant, $Z = 7.05$, $p < .00001$. Sequential priming measures thus showed specificity, only predicting behavior when within-study moderators predicted that they would.

For the 22 studies in the attitudes meta-analysis that included within-study moderators, the effect size for the

Table 2. Description of Theoretical Moderator Variables

	Behavior					Attitudes				
Moderator definition	*k*	Minimum	Maximum	*M*	*SD*	*k*	Minimum	Maximum	*M*	*SD*
Controllability of response to the criterion measure (range = 1-5)	86	1	5	4.10	.95	116	3	5	4.58	.57
Social sensitivity of response to the criterion measure (range = 1-5)	86	1	5	3.78	.91	116	1.5	5	4.00	1.12
Correlation between priming task and explicit attitude measure	34	−.24	.65	.20	.24					
Correlation between explicit attitude measure and behavior	38	−.33	.96	.25	.30					

predicted condition was $r = .36$ ($p < .00001$, $Q = 16.45$). For the nonpredicted condition, the effect size was $r = -.01$ ($p = .89$, $Q = 21.55$). These effect sizes were significantly different, $Z = 8.58$, $p < .0001$, suggesting that sequential priming measures and explicit attitude measures only converged when theory expected them to.

Moderators coded from dual-process theories. For the six studies in the behavior meta-analysis that included within-study moderators based clearly on dual-process theories, the effect size for the predicted condition was $r = .45$ ($p < .00001$, $Q = 25.62$). However, for the nonpredicted condition, the effect size was $r = .06$ ($p = .46$, $Q = 15.68$). The difference between these aggregate effect sizes was significant, $Z = 3.45$, $p = .001$. Sequential priming measures predicted behavior only under conditions predicted by within-study moderators based on dual-process theories.

For the 15 studies in the attitudes meta-analysis that included within-study moderators based on dual-process theories, the effect size for the predicted condition was $r = .39$ ($p < .00001$, $Q = 10.76$). However, for the nonpredicted condition, the effect size was $r = -.03$ ($p = .65$, $Q = 19.86$). The difference between these aggregate effect sizes was significant, $Z = 6.52$, $p < .00001$. Sequential priming measures predicted explicit attitudes only under conditions predicted by within-study moderators based on dual-process theories.

Finally, social sensitivity is of particular interest as a within-study dual-process theory moderator, because most dual-process theories predict that implicit and explicit attitudes will converge under conditions of low self-presentational pressure (Chaiken & Trope, 1999). Eleven samples reported effect sizes at different levels of a social sensitivity moderator (e.g., motivation to control prejudice). Under conditions of low social sensitivity, the relationship between priming and explicit attitude measures was $r = .28$ ($p < .00001$, $Q = 6.80$). Under conditions of high social sensitivity, the effect size was $r = -.03$ ($p = .71$, $Q = 15.82$). The difference between these aggregate effect sizes was significant, $Z = 3.47$, $p < .0001$. The relationship between sequential priming and explicit attitude measures was moderated by social sensitivity, consistent with dual-process theory predictions.

Between-Study Theoretical Moderators

To complement the within-study analyses, we examined the effects of theoretically relevant between-study moderators, including controllability and social sensitivity of the criterion measure. Based on previous findings that implicit tests may better predict behavior when there is little conflict between implicit and explicit attitudes, we also examined whether the correlation between implicit and explicit attitude measures moderated the association between priming and behaviors. Descriptive statistics of the between-study theoretical moderators are presented in Table 2.

Because controllability and social sensitivity were correlated ($r = .16$, $p = .02$), we conducted a simultaneous weighted regression analysis in which both variables were entered as moderators. These results are presented in Table 3. For the behavior meta-analysis, neither of these between-study variables moderated the priming-behavior relationships. Sequential priming measures still predicted behavior when including controllability and social sensitivity in the model (intercept B = .33, $z = 2.27$, $p = .02$). Finally, controllability and social sensitivity each did not predict behavior or attitudes when entered as single moderators in univariate regression analyses (all ps > .47). Thus, sequential priming measures successfully predicted behavioral outcomes despite variations in the controllability and social sensitivity of responding to the criterion measures.

As with the behavior findings, neither of the between-study theoretical moderators predicted variance in the relationship between priming and explicit attitudes. Sequential priming measures still predicted explicit attitudes when including controllability and social sensitivity in the model (intercept $B = .32$, $z = 2.18$, $p = .03$). Thus, sequential priming measures were associated with explicit attitudes despite variations in these theoretical moderators.

Next, we examined whether the correlation between priming measures and explicit attitudes moderated the relationship between priming measures and behaviors. There were 34 samples that reported both types of relationship. As seen in Table 3, stronger implicit-explicit attitude correlations

Table 3. Tests of Weighted Regression Models for Theoretical Moderators

	Behavior				Attitudes			
Moderator	β	*k*	*z*	*p*	β	*k*	z	*p*
Controllability	−.06	86	−.45	.65	−.07	116	−.70	.48
Social sensitivity	.01	86	.09	.93	−.04	116	−.39	.70
Priming-explicit attitude correlation	.47	34	2.56	.01				

Note: Analyses were conducted with mixed-effects models (fixed slopes, random intercepts). *k* = number of samples in each analysis; β = standardized regression coefficient; *z* = critical ratio test for the regression coefficient; *p* = two-tailed probability of *z*. The first two moderators were tested together in a simultaneous regression model. Summary statistics for the simultaneous regressions are R^2 =.003 for the behavior model and R^2 = .01 for the attitudes model.

Table 4. One-Way ANOVA Model for Study Domain

	Behavior						Attitudes					
Moderator	Moderator subgroup	*r* (95% CI)	*k*	*SE*	Q_{Bet}	p_Q	Moderator subgroup	*r* (95% CI)	*k*	*SE*	Q_{Bet}	p_Q
Study domain	Overall	.28 (.23, .33)	70	.03	1.15	.89	Overall	.20 (.17, .24)	114	.02	12.21	.06
	Personality	.34 (.21, .47)	10	.07			Personality	.15 (.02, .28)	8	.07		
	Close relationships	.28 (.11, .44)	6	.08			Close relationships	.17 (.02, .32)	5	.08		
	Prejudice	.28 (.20, .36)	30	.04			Prejudice	.17 (.13, .22)	66	.02		
	Impulsive behaviors	.25 (.17, .34)	24	.05			Impulsive behaviors	.24 (.12, .37)	8	.06		
	Political preferences		*k* < 5				Political preferences	.38 (.26, .50)	7	.06		
	Consumer preferences		*k* < 5				Consumer preferences	.25 (.11, .39)	6	.07		
	Other		*k* < 5				Other	.22 (.13, .31)	14	.05		
	Clinical		*k* < 5				Clinical		*k* < 5			

Note: Results are from a mixed-model ANOVA of differences among the categories of the moderator. Levels of a moderator were excluded from analysis if they had less than five samples. Overall effect size represents the weighted mean effect size collapsing across all samples included in the moderation analysis. Effect sizes for each moderator subgroup are presented in descending order for behavior. *r* = weighted mean effect size with 95% confidence intervals (CIs); *k* = number of samples associated with each weighted mean effect size; *SE* = standard error of the weighted mean effect size, Q_{Bet} = homogeneity statistic for the moderator; p_Q = significance level of the homogeneity statistic for the moderator. The *Q* statistics for each of the respective levels of each moderator were all nonsignificant for the behavior and attitudes analyses.

predicted stronger relationships between priming and behavioral outcomes, β = .47, Z = 2.56, p = .01, R^2 = .22. Sequential priming still predicted behavior when including implicit–explicit correlation as a moderator (intercept B = .24, z = 4.76, p < .0001). Thus, as in Greenwald and colleagues (2009), stronger convergent validity was associated with stronger predictive validity.

Domain of Study

Table 4 presents aggregate effect sizes by study domain. In this model, the aggregate effect size ("Overall") represents the grand mean effect size of all samples included in the analysis. For the behavior results, there was not significant heterogeneity in effect sizes based on type of domain studied. By contrast, there was marginally significant heterogeneity for effect sizes by study domain in the attitudes meta-analysis. Studies of political preferences had the strongest effect size (r = .38), followed by consumer preferences (r = .25) and impulsive behaviors (r = .24). Associations for prejudice (r = .17), close relationships (r = .17), and personality (r = .15) were smaller. Overall, the effects of topic of study were rather small. In general, these findings suggest that priming tasks may be predictive of behaviors and, to some extent, explicit attitudes across a broad range of topics.

Type of Priming Task

For the behavior results, there was not significant heterogeneity in effect sizes based on type of priming task (see Table 5). In contrast, results of the attitudes meta-analysis revealed significant heterogeneity. The largest associations included the AMP (r = .30) and lexical decision task (r = .18). The

Table 5. One-Way ANOVA Model for Type of Priming Task

	Behavior						Attitudes					
Moderator	Moderator subgroup	*r* (95% CI)	*k*	*SE*	Q_{Bet}	p_Q	Moderator subgroup	*r* (95% CI)	*k*	*SE*	Q_{Bet}	p_Q
Priming task	Overall	.28 (.23, .33)	73	.03	3.05	.22	Overall	.21 (.18, .24)	110	.02	25.76	.00001
	AMP	.35 (.25, .44)	18	.05			AMP	.30 (.25, .35)	46	.03		
	Lexical decision task	.29 (.18, .41)	13	.06			Lexical decision task	.18 (.04, .31)	7	.07		
	Evaluative priming task	.25 (.18, .31)	42	.03			Evaluative priming task	.13 (.08, .18)	52	.03		
	Shooter task		$k < 5$				Shooter task	.08 (−.08, .24)	5	.08		
	Weapon identification task		$k < 5$				Weapon identification task		$k < 5$			
	Flanker task		$k < 5$				Flanker task		$k < 5$			
	Other priming		$k < 5$				Other priming		$k < 5$			

Note: AMP = affect misattribution procedure. Results are from a mixed-model ANOVA of differences among the categories of the moderator. Levels of a moderator were excluded from analysis if they had fewer than five samples. Overall effect size represents the weighted mean effect size collapsing across all samples included in the moderation analysis. Effect sizes for each moderator subgroup are presented in descending order for behavior. *r* = weighted mean effect size with 95% confidence intervals (CIs); *k* = number of samples associated with each weighted mean effect size; *SE* = standard error of the weighted mean effect size, Q_{Bet} = homogeneity statistic for the moderator; p_Q = significance level of the homogeneity statistic for the moderator. The *Q* statistics for each of the respective levels of each moderator were all nonsignificant for the behavior and attitudes analyses. AMP = affect misattribution procedure.

evaluative priming task (r = .13) and shooter task (r = .08) had the lowest associations with explicit measures. The AMP displayed the strongest implicit-explicit correspondence, possibly because it tends to have higher reliability than response-time tasks (Payne et al., 2005). A second reason may be that the AMP has greater structural correspondence to explicit attitude measures because the dependent variable in each case is an evaluative judgment (Payne et al., 2008).

An alternative explanation is that the AMP may correlate more strongly with explicit measures because it is more "explicit" than other tasks. To assess this explanation, we conducted the same within-study dual-process moderators analysis from earlier, including only studies utilizing the AMP. Twelve studies included variables related to automatic versus controlled processing as moderators of the relationship between the AMP and explicit measures. Specifically, these studies included variables related to either the motivation or ability to respond deliberatively. According to dual-process theories (e.g., Fazio, 1990), implicit tasks should be more strongly related to explicit tasks under conditions that discourage controlled responding. The analysis indicated that the aggregate relationship between AMP and explicit measures was substantial under conditions that discouraged deliberate responding on explicit measures, r = .36. In conditions that encouraged deliberative responding on explicit measures the aggregate relationship was only r = −.003. The difference between these values was significant, Z = 5.14, p < .00001. The AMP thus displayed a pattern of specificity that is typical of implicit measures.

Between-Study Methodological Moderators

The next set of moderators was methodological, having to do with features of the sequential priming task, criterion measure, and experimental setting. Descriptive statistics of the task-related moderators are presented in Table 6. Methodological moderators were examined individually using weighted univariate regressions.[2] Results of these regression analyses are presented in Table 7. For all univariate regression analyses, implicit measures still predicted behavior and attitudes when including a given methodological moderator (intercept Bs ranged from .17 to .37, all ps < .01).

Most of the priming task parameters—number of trials, prime type, conscious versus subconscious prime presentation, prime duration, SOA, and interstimulus interval—did not influence the relationship between priming and behavior. The association with behavior was also not influenced by whether the behavior was observed by the experimenter (e.g. an actual behavior) or reported by the participant (e.g., a behavioral intention or reports of past behavior). This effect did not appear to reflect differences in ecological realism, because realism did not moderate the association between priming and behavior.

The only task parameter that influenced the priming-behavior relationship was target duration: Longer target durations were marginally associated with a decreased relationship between sequential priming and behavior, β = −.25, Z = −1.83, p = .07, R^2 = .06. Similarly, the only task

Table 6. Description of Methodological Moderator Variables

	Behavior					Attitudes				
Moderator definition	*k*	Minimum	Maximum	*M*	*SD*	*k*	Minimum	Maximum	*M*	*SD*
Number of trials on priming task	73	12	720	153.11	121.15	90	36	432	133.93	82.37
Word *(0)* vs. image *(1)* prime	84	0	1	.58	.50	94	0	1	.78	.42
Subconscious *(0)* vs. conscious *(1)* prime presentation	85	0	1	.69	.46	95	0	1	.76	.43
Duration of prime (ms)	81	15	5,000	255.75	770.47	87	15	1,250	154.60	184.77
Duration of target (ms)	82	100	5,000	2,709.24	2,280.94	82	100	2,500	797.99	908.39
Time between onset of prime and onset of target (SOA; ms)	80	0	1,350	259.08	217.76	88	0	2,015	265.05	287.32
Time between trials (ms)	51	400	4,000	1,619.26	744.20	67	100	3,500	1,225.67	727.93
Subject- *(0)* vs. experimenter-observed *(1)* criterion measure	83	0	1	.23	.42					
Field *(0)* vs. lab *(1)* setting	86	0	1	.88	.32	96	0	1	.80	.40
Ecological realism of the criterion measure (range = 1-5)	86	1	5	2.85	1.26	116	1	3.5	1.80	.54
Unpublished *(0)* vs. published *(1)*	86	1	1	1.00	0.00	116	0	1	.78	.41
Article publication year	86	1995	2011	2006	3.80	91	1995	2011	2006	4.26

Table 7. Tests of Weighted Regression Models for Methodological Moderators

	Behavior				Attitudes			
Moderator	β	*k*	*z*	*p*	β	*k*	*z*	*p*
Number of trials	−.13	73	−.88	.38	.01	90	.06	.95
Image prime (vs. word prime)	.06	84	.45	.65	.15	94	1.51	.13
Conscious prime (vs. subconscious prime)	.04	85	.32	.75	.13	95	1.29	.20
Prime duration	−.13	81	−.96	.33	−.12	87	−1.08	.28
Target duration	−.25	82	−1.83	.07	−.34	82	−3.15	.002
SOA	−.06	81	−.60	.55	−.11	88	−1.01	.31
Intertrial interval	.03	54	.17	.86	−.04	67	−.31	.76
Published (vs. unpublished)		*k* < 5			.01	116	.07	.94
Publication year	.07	86	.53	.59	.27	91	2.59	.01
Lab setting (vs. field)	.18	86	1.46	.14	.07	96	.73	.47
Ecological realism	−.08	86	−.67	.51				
Subject-observed criterion (vs. experimenter-observed)	−.04	83	−.28	.78				

Note: These univariate regression analyses were conducted with mixed-effects models (fixed slopes, random intercepts). *k* = number of samples in each analysis; β = standardized regression coefficient; *z* = critical ratio test for the regression coefficient; *p* = two-tailed probability of *z*; SOA = stimulus onset asynchrony. Analysis for number of trials includes effect code for task type (1 = *affect misattribution procedure*, −1 = *all other types of priming tasks*) as a covariate.

parameter that influenced the relationship between priming and explicit attitudes was target duration. Longer target durations were associated with a decreased relationship between sequential priming and explicit attitude measures, β = −.34, $Z = -3.15$, $p = .002$, $R^2 = .12$.

Finally, we examined whether year of study publication influenced predictive and convergent validity. Although publication year did not moderate the relationship between priming and behaviors, it did moderate the relationship between priming and explicit attitudes. More recent studies showed stronger relationships between priming tasks and attitude measures, β = .27, $Z = 2.59$, $p = .01$, $R^2 = .07$. This suggests that the field may be making progress in developing high quality implicit and explicit measures. Another possibility is that publication year is related to research domain: whereas, earlier studies using sequential priming examined prejudice—and found that implicit-explicit correlations were often small—more recent studies have examined domains such as political and consumer preferences, where such correlations are often much larger.

Discussion

A meta-analysis of 167 independent studies revealed that sequential priming tasks were reliably associated with relevant behaviors ($r = .28$) and explicit measures ($r = .20$). The association between implicit attitudes and behaviors was not significantly different from the association between explicit attitudes and behaviors. Moreover, priming reliably predicted behaviors after controlling for the association between explicit attitudes and behavior. Many controversies over the meaning and usefulness of implicit measures hinge on the question of whether implicit measures are valid predictors of behavior and preferences. A comprehensive examination of all available data suggests that priming tasks, as a class, are indeed valid measures.

Behavior. The association between priming and behaviors displayed a striking degree of generality. Associations were similar across the various priming tasks examined. They were similar across the various topics studied, from personality to impulsive behaviors, to prejudice, to close relationships. Associations were similar for ecologically realistic and unrealistic measures of behavior. Finally, they were similar across behavioral measures that differed in controllability and social sensitivity.

One common hypothesis is that implicit tests may be associated selectively with uncontrollable behaviors, whereas explicit tests may be associated with deliberate, controllable behaviors (e.g., Dovidio, Kawakami, & Gaertner, 2002). Other researchers, however, have suggested that this "double dissociation" is only one of many meaningful patterns that are consistent with attitude theories. Perugini, Richetin, and Zogmaister (2010) reviewed evidence consistent not only with double dissociations but also with additive patterns (in which implicit and explicit test each predict more and less controllable behaviors) and interactive patterns (in which the interaction of implicit and explicit measures predicts behavior). The present results are consistent with this broader view. Priming measures were associated with controllable and uncontrollable behaviors, and with socially sensitive and socially innocuous behaviors.

This, of course, does not mean that there are no boundaries on the relationship between priming tasks and behavior. When we examined the effects of within-study moderators, we found strong evidence for moderation by factors that researchers have tested within individual studies. Many of these within-study moderators were related to the same theoretical distinctions that we tested in the between-study comparisons. For example, preference for intuition (Hofmann & Baumert, 2010; Studies 1 and 2) is related to whether behaviors are more or less controllable. Moreover, motivation to control prejudiced reactions (Olson & Fazio, 2004; Payne et al., 2005; Study 6) and social pressure (Payne et al., 2008; Study 4) are related to social sensitivity. There was evidence that these factors did indeed moderate the association between priming and behaviors, at least within studies.

Why might the results of between-study moderators differ from within-study moderators? The measures in the between-study analysis differed from each other in multiple ways, in addition to the variables coded. In contrast, all of the within-study comparisons held constant the behavioral dependent variable. Within-study variables afford greater experimental control that may make it easier to detect effects against a background of error variance. The comparison of within-study moderators and between-study moderators suggests that the specificity of priming measures is not to be found in whether they predict one broad type of behavior versus another type. Instead, priming appears to be more strongly associated with behavior under some processing conditions rather than others. In other words, specificity may be found not in the type of outcome, but in the types of processing engaged. Based on these results, future research may make faster progress by studying the processes engaged in performing a given behavior, rather than by contrasting different classes of behaviors.

Explicit measures. As with behaviors, the association between priming tasks and explicit measures displayed some generality. Priming was associated with explicit measures across laboratory and field settings. Priming was associated with explicit measures regardless of their controllability and social sensitivity at the between-study level. Yet, within-study moderators showed significant effects. In conditions where no implicit-explicit correspondence was hypothesized, the correlation was near zero. Many of these moderators were related to controllability or social sensitivity. In fact, social sensitivity was a significant moderator when examined alone as a within-study variable. As with behaviors, the comparison of between-study moderators and within-study moderators suggests that the specificity of priming measures may be more likely to rely on the processes engaged as participants complete the measures, rather than on characteristics of the explicit measures.

The type of priming task, however, appeared to affect implicit-explicit correspondence. Studies employing an AMP showed the greatest correspondence with explicit measures. The association between the AMP and explicit measures ($r = .30$) was similar to its association with behavior ($r = .35$). Whereas lexical decision tasks and evaluative priming tasks showed comparable relationships with behavior, they were less reliably associated with explicit measures.

We considered three reasons that the AMP may display higher correspondence with explicit attitudes. We found no evidence that the AMP was more controllable or less implicit than other tasks. Moderator analyses suggested that AMP responses were associated with explicit measures only under conditions of low motivation or ability to respond deliberatively, as predicted by dual-process theories. Instead, the differences may be driven by the reliabilities of different priming measures. Although reliability was not reported frequently enough to code in the present analysis, previous

research suggests that the AMP is more reliable than other priming tasks. Finally, the AMP may have greater methodological similarity with explicit attitude measures because both rely on evaluative ratings. These findings suggest that to maximize effect sizes without sacrificing specificity in future studies, researchers should consider the reliability of the implicit task as well as methodological similarity between implicit and explicit measures.

Methodological lessons. The meta-analysis revealed several methodological insights that may be of use to researchers. One perhaps surprising finding was that target duration was a significant moderator of the relation between priming and explicit measures but prime duration, subliminal versus visible priming, and the intervals between stimuli were not. This finding highlights the important of considering not only responses to primes but also how primes affect the processing of targets. It is consistent with previous research that priming effects are stronger when the target stimuli are degraded (De Houwer, Hermans, & Spruyt, 2001). When targets are degraded or presented only briefly, participants may rely more heavily on primed information to help disambiguate the targets.

The absence of effects for prime duration should be interpreted only within the relatively narrow range of durations in the studies reviewed here. In most studies, researchers present primes in the range of milliseconds rather than seconds because they are interested in capturing fast-acting automatic processes. There may not be enough variability in prime durations in these studies to detect systematic effects. In fact, the standard deviations for prime duration (SD = 770.47 ms for behavior; 184.77 ms for attitudes) were smaller than the standard deviations for target duration (SD = 2,280.94 for behavior; 908.39 ms for attitudes). The same cautions apply when interpreting effects of SOA and time between trials. There was relatively little variation in these, most likely because experimenters tend to use a common set of durations in most studies.

The contrast between subliminal and visible primes, in contrast, is not limited in this way. Twenty-six studies in the behavior analysis and 23 studies in the explicit attitudes analysis presented primes subliminally. Given this sample size, the lack of any difference between subliminal and visible primes seems meaningful. If subliminality makes little difference to the validity of priming tasks, then researchers may find it convenient to avoid methodological problems associated with subliminal priming such as difficulty verifying the absence of awareness (Reingold & Merikle, 1988; see also, Bargh, 1992).

One further finding about task structure deserving note is that the number of trials in the task had no significant effect. This seems counterintuitive because more observations generally lead to increased reliability, which should improve the ability to detect significant relationships. However, researchers may add trials to compensate for low reliability in some tasks. Consistent with this idea, the AMP—which generally has high reliability—averaged 77 trials across studies, whereas evaluative priming tasks averaged 166 trials and lexical decision tasks averaged 196 trials. If researchers use more trials in tasks that have lower reliability in general, then this would obscure the relationship between number of observations and reliability expected by classical test theory.

One critique of implicit social cognition research is that it may not generalize to ecologically realistic situations. Contrary to this notion, we found that priming tasks predicted outcome measures about equally well regardless of whether the outcome was high or low in ecological realism, experimenter-observed or self-reported, or studied in laboratory or field settings. These findings suggest that the utility of priming tasks is not limited to artificial settings. These results should encourage researchers to apply implicit methods in field studies and with realistic measure of behavior to maximize the impact of research findings.

Comparison to other meta-analyses of implicit attitudes. Two other meta-analyses of implicit attitudes have been published recently, both focusing on the Implicit Association Test. The effect sizes reported here are comparable to meta-analyses of the IAT. Greenwald and colleagues (2009) reported an average correlation of r = .27 between the IAT and behavior, and an average correlation of r = .21 between the IAT and explicit measures. Hofmann and colleagues (2005) reported an average correlation of r = .24 between the IAT and explicit measures. With average effect sizes of .28 for behavior and .20 for explicit measures, priming tasks appear to be about equally effective as the IAT for predicting a wide range of behaviors and explicit measures.

Consistent with the analysis of Greenwald and colleagues (2009), we found that priming was more strongly related to behaviors when the implicit-explicit relationship was stronger. This provides further evidence that a lack of ambivalence, reflected in high implicit-explicit correspondence, may lead to stronger behavior prediction (Petty & Krosnick, 1995). This relationship is not specific to either the IAT or priming measures but appears to be a general feature of implicit attitudes.

Also consistent with present results, Hofmann and colleagues (2005) found no evidence that the social desirability of the explicitly measured topic moderated implicit-explicit associations when coded at the study level. In contrast, Greenwald and colleagues (2009) found that social sensitivity was a significant moderator of the IAT-behavior relation. The differences may reflect the fact that each of these analyses used different subjective coding methods to quantify social desirability or social sensitivity. Our within-study analyses suggest that measures and manipulations of social sensitivity, such as motivation to control prejudice, were a significant moderator of the relationship between implicit and explicit attitudes.

Conclusion

In a comprehensive meta-analysis of 167 studies, we found that priming tasks function well as measures of implicit social cognition. They were significantly associated with behavioral measures and explicit attitude measures, and these associations generalized across a wide range of study contexts and methodological variations. The effect sizes of these associations were comparable to the implicit association test, and also comparable to the relationship between explicit attitudes and behavior. Among the earliest methods developed for measuring automatic associations, priming tasks continue to offer an attractive means to measure individual differences in implicit social cognition.

Authors' Note

C. Daryl Cameron and Jazmin Brown-Iannuzzi contributed equally to the development of this project.

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Notes

1. When entered on its own without taking into account type of priming task, number of trials emerged as a significant moderator of the relationship between sequential priming measures and explicit attitudes, $\beta = -.29$, $Z = -2.86$, $p = .004$, $R^2 = .08$. This result would imply that having a sequential priming task with more trials actually decreases its convergent validity. Without accounting for type of priming task, this result is counterintuitive and difficult to interpret. In the main text, the reported analysis controls for whether or not the priming task used was the AMP and removes this effect. In addition, we conducted an exploratory analysis testing the interaction between number of trials and the dummy-coded AMP variable. Number of trials did not differentially influence implicit-explicit correlations depending on whether the AMP was used, $\beta = -.04$, $p = .94$.
2. A second way to approach the problem of publication bias is to estimate the number of unpublished studies with null results that would have to exist to reduce the meta-analytic effects to nonsignificance. Based on Rosenthal's (1979) fail-safe statistic, we found that 409,846 studies with null effects would be needed to render the priming-behavior relationship nonsignificant, and 502,681 studies to eliminate the implicit-explicit relationship. Although these numbers are extremely large, this is not unusual with the fail-safe statistic; in his description of the fail-safe statistic, Rosenthal (1979) summarized previous research showing that in 311 studies with a mean Z of 1.18, the fail-safe statistic was 49,457 studies. Given our high Z statistics ($Z_{Behavior} = 12.25$, $Z_{Attitudes} = 10.06$), it is not surprising that the fail-safe statistics are so large. A potential weakness of the fail-safe statistic is that it only tests the number of studies with effect sizes of zero needed to render the meta-analytic effect nonsignificant. Publication bias might also screen out studies with negative effect sizes (i.e., significant effects in the direction opposing the hypothesis). It would take many fewer such studies to render net effects nonsignificant. Therefore, we relied primarily on funnel plots and testing the meta-analytic effect of published versus unpublished studies to assess the impact of publication bias.

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