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THE IMPLICIT ASSOCIATION TEST'S *D* MEASURE CAN MINIMIZE A COGNITIVE SKILL CONFOUND: COMMENT ON McFARLAND AND CROUCH (2002)

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McFarland and Crouch (2002) reported substantial positive correlations (a) between the Implicit Association Test (IAT) and response speed and (b) between IATs assessing racism or self-esteem and ostensibly unrelated control IATs. Using an IAT measure in millisecond-difference score format, they concluded that the IAT was confounded with general cognitive ability. A reanalysis of these data using the *D* measure (Greenwald, Nosek, & Banaji, 2003) eliminated the speed of responding confound, although it did not eliminate the correlation between the control and racism IATs. The study was replicated and the two correlations, paralleling those in the original study, emerged for the millisecond-difference score. However, both were reduced to nonsignificance by use of the *D* measure. These findings are consistent with other recent studies (Mierke & Klauer, 2003) that document the protection afforded by *D* against cognitive skill confounds.

The Implicit Association Test (IAT) indirectly measures relative strengths of associations between concepts and attributes (Greenwald, McGhee, & Schwartz, 1998). In the IAT, it is easier to give the same response to items representing two concepts when they are

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well associated than when they are not. For example, in an IAT involving the pair of object concepts, *flowers* and *insects*, and the pair of attribute concepts, *pleasant* and *unpleasant*, it is easy to give one response to flower names and pleasant words while giving a different response to insect names and unpleasant words (*congruent* arrangement), whereas it is relatively difficult to give one response to flower names and unpleasant words while giving a different response to insect names and pleasant words (*incongruent* arrangement). The IAT effect is the performance difference between two such conditions and is understood to reflect the relative strengths of associations between the IAT concepts and attributes.

The IAT has been used to measure *implicit attitudes*, which are conceived of as associations involving objects and evaluative attributes (Cunningham, Preacher, & Banaji, 2001; Marsh, Johnson, & Lori, 2001; McConnell & Leibold, 2001; Rudman & Kilianski, 2000), *implicit stereotypes* (Greenwald et al., 1998), *implicit self–esteem* (Greenwald et al., 2002; Greenwald, & Farnham,2000; Farnham, Greenwald, & Banaji, 1999; Jordan, Spencer, Zanna, Hoshino–Browne, & Correll, 2003), and *implicit self–concept* (Egloff & Schmukle, 2002; Greenwald et al., 2002; Swanson, Rudman, & Greenwald, 2001). Evidence for the construct validity of the IAT as an implicit measure of individual differences is steadily accumulating (in addition to the foregoing, see Greenwald & Nosek, 2001; Ottaway, Hayden, & Oakes, 2001; Phelps et al., 2000; Poehlman, Uhlmann, Greenwald, & Banaji, 2003).

In a recent article, McFarland and Crouch (2002) concluded that the IAT contains an artifact associated with cognitive skill and observed that “some individuals may have greater difficulty than others in responding to incongruent categories relative to congruent ones independent of the specific content of the IATs”(p. 845). Their study included implicit race prejudice and implicit self–esteem IATs. Two control IATs, delicious and flower IATs, representing conceptual associations unrelated to race prejudice and self–esteem, were also incorporated. The delicious IAT measured the association between “delicious” and “happy” (the contrasting concepts were “not delicious” and “unhappy”). The flower IAT measured the association between “flowers” and “pleasant” (the contrasting concepts were “insects” and “unpleasant”) as in Greenwald et al. (1998).

McFarland and Crouch (2002) used a millisecond–unit measure of the IAT effect, in contrast to the measure based on log–transformed latencies that was introduced by Greenwald et al. (1998) and that has been used in most subsequent published IAT research. Using the millisecond–unit difference measure, McFarland and Crouch found that the two control IATs correlated positively with both the Race and self–esteem IATs. Because these relationships had no obvious basis in terms of the typical association–strength interpretation of IAT effects, McFarland and Crouch concluded that they were likely due to a cognitive skill confound common to all IATs.[1] The possibility of a cognitive skill confound in the IAT has been considered in some other recent studies (Mierke & Klauer, 2001, 2003). In a study assessing implicit age cognitions (Hummert, Garstka, O'Brien, Greenwald, & Mellott, 2002), elderly subjects who responded more slowly showed larger implicit effects on the conventional IAT measure. However, when the latencies were transformed by using as a divisor a within–subject overall standard deviation (*SD*), this age–related confound was minimized.

More recently, a new IAT effect measure, *D*, was presented by Greenwald et al. (2003). *D* rescales individual IAT effects by within–participant latency variability. An overall latency *SD* from the IAT's two combined tasks is computed for each participant. *D* is the millisecond-difference score divided by this *SD* (see details in Greenwald et al., 2003). Compared to several alternatives, *D* was more effective in (a) suppressing variability in the measure related to response speed and (b) capturing individual differences related to association strength (Greenwald et al., 2003). We expected that this *D* measure would reduce the cognitive skill confound that was described by McFarland and Crouch.

REANALYSIS OF MCFARLAND AND CROUCH (2002)

Data from Study 4 and Study 3 of the McFarland and Crouch (2002) article were available for analysis. Study 4 incorporated the two control IATs along with race and self-esteem IATs. Only data of the delicious and racism IATs in Study 3 were analyzed. The

1. McFarland and Crouch (2002) mistakenly concluded regarding this cognitive skill that "Those who lack this skill are biased toward . . . lower self-esteem IAT scores" (p. 483). But because response speeds reflecting positive self-esteem are subtracted from those reflecting negative self-esteem, larger IAT scores indicate higher self-esteem, and lacking the cognitive skill actually biases participants toward higher self-esteem IAT scores. McFarland and Crouch acknowledge and regret this error.

TABLE 1. Correlations Between IAT Effects and Mean Latency

	IAT							
	Delicious		**Flower**		**Racism**		**Self–Esteem**	
	Ms	***D***	**Ms**	***D***	**Ms**	***D***	**Ms**	***D***
Mean latency	.53**	–.17	.28*	–.23	.50**	–.10	.37**	–.12

Note. The table is based on data of study 4 of McFarland and Crouch's (2002) research. $n = 55–59$. "Mean latency" is based on combined blocks across four IATs. Ms = millisecond measure. D = D measure. *$p < 0.05$; **$p < 0.01$.

millisecond–unit measure used by McFarland and Crouch and *D* were used in the reanalysis. The millisecond measure was based on the test blocks, and latencies more extreme than the range (300, 3000) were truncated to the corresponding boundary value. The *D* measure used both the practice and test blocks and was computed as described in detail by Greenwald et al. (2003).

STUDY 4

Table 1 displays the correlations between the four IATs on the one hand and mean latencies on the other. The millisecond measure has substantial large positive correlations with mean latencies. The millisecond-difference measure is clearly confounded with speed of responding. By contrast, the *D* measure is unrelated to mean latency. By scaling individual latency differences by latency variability, *D* successfully makes the IAT independent of speed of responding.

Table 2 displays the correlations among the four IATs in the study. The delicious IAT is positively correlated with the racism IAT for both the millisecond (r = .39) and *D* (r = .38) measures. The self–esteem IAT is not correlated with the control IATs for either measure. The correlation between implicit self–esteem and implicit racism was smaller for *D* than for the millisecond measure (.25 vs. .09).

STUDY 3

For this study, separate samples were used to examine the effects of the cognitive confound on the racism and self–esteem IATs. The delicious–racism IAT correlations were .50 for both the millisecond and

TABLE 2. Correlations Among IAT Effects

	Delicious		Flower		Racism	
	Ms	***D***	**Ms**	***D***	**Ms**	***D***
Flower	.42**	.58**				
Racism	.39**	.38**	.05	.22		
Self–Esteem	.21	.11	.19	.25	.25*	.09

Note. The table is based on data of Study 4 of McFarland and Crouch's (2002) research. n = 55–59. Ms = millisecond measure. D =D measure. *$p < 0.05$; **$p < 0.01$.

D measures. Partialling out average latency from the millisecond and *D* measures did not reduce the magnitude of the delicious–racism IAT correlations (*r*s = .45 and .49). Thus, the correlation between the control and racism IATs is not simply based on individual differences in speed of responding. On the second sample, the delicious–self–esteem IAT correlation of .35, p = .05 (n = 34) for the millisecond measure was reduced to .21, p = .24 for the *D* measure; using the *D* measure reduced the cognitive confound to nonsignificance. The results for the delicious–racism IAT may be anomalous findings that are unlikely to replicate, or some unknown, but substantively meaningful, factors produced the correlation. To choose between these two alternatives, we conducted a replication study that used the delicious and racism IATs with a student sample at the University of Washington.

REPLICATION STUDY

METHOD

Participants. 101 undergraduates at the University of Washington participated in the study in exchange for course credit.

Procedure. After providing consent and completing demographic information, participants were presented with the delicious and racism IATs used by McFarland and Crouch (2002; see Appendix for the target and attribute exemplars).

Participants completed two seven–block IATs measures (Greenwald et al., 1998) for the delicious IAT and the racism IAT. In the combined tasks, there were 24 trials in the practice blocks and 40 trials in the succeeding test blocks. Concept and attribute trials alternated in combined–task blocks, and subjects were required to correct errors in responding by pressing the alternative key in order to continue—a built–in latency penalty for incorrect responses, as recommended by Greenwald et al. (2003) and as used by McFarland and Crouch (2002). The two possible sequences of the two IATs were counterbalanced across participants. Within each sequence, half the subjects did both IATs so that the presumably congruent blocks (e.g., *delicious* paired with *pleasant* and *not delicious* paired with *unpleasant*) preceded the incongruent blocks; this order was reversed for other participants. To help subjects distinguish concept items from attribute items, in many IATs concept and attribute exemplars appear in different fonts or colors. That was not done in McFarland and Crouch's (2002) experiments. To determine whether that might have contributed to their findings, the present replication used, as a between–subjects variation, both their procedure (*same color* condition, all concept and attribute exemplars in black) and a *varied color* condition, with concept exemplars in blue and attribute exemplars in green.

RESULTS

The correlations between IAT effects and average latency, for the millisecond measure, were substantially positive for both the delicious ($r = .65$, $p = 10^{-13}$, $n = 101$) and racism IATs ($r = .49$, $p = 10^{-7}$, $n = 101$). This response speed related cognitive confound was removed by the use of the *D* measure; the correlations were near zero for both the delicious ($r = .01$, $p = .96$, $n = 101$) and racism IATs ($r = .05$, $p = .63$, $n = 101$). These results are similar to those obtained in the reanalysis of Study 4. The correlation between racism and delicious IATs, for the millisecond measure, was substantially positive ($r = .35$, $p = 10^{-4}$), indicating shared variance between the IATs. Thus, the correlation between the racism and delicious IATs, as reported by McFarland and Crouch (2002) was successfully replicated. However, this correlation emerged only for the millisecond measure. This correlation was reduced to non-significance ($r = .17$, $p = .09$) for *D*. Unlike the data from McFarland and Crouch's Experiments 3 and 4, in the present replication the *D* measure reduced the presumably artifactual correlation between these two IATs to statistical nonsignificance. This makes it plausible that this aspect of McFarland and Crouch's results may have been associated with unique aspects of the sample or data collection procedures.

TABLE 3. IAT effects (Ms and *D* measure) of Replication Data

	Racism→Delicious				Delicious→Racism			
	C→I		I→C		C→I		I→C	
	Ms	***D***	**Ms**	***D***	**Ms**	***D***	**Ms**	***D***
Delicious IAT								
Same color	573 (177)	1.214 (.185)	439 (184)	1.102 (.271)	630 (157)	1.208 (.177)	595 (231)	1.208 (.202)
Varied color	519 (272)	1.074 (.224)	295 (153)	.998 (.171)	542 (145)	1.186 (.190)	428 (124)	1.084 (.235)
Racism IAT								
Same color	252 (111)	.804 (.322)	86 (57)	.423 (.627)	245 (132)	.636 (.243)	123 (73)	.500 (.227)
Varied color	287 (200)	.784 (.313)	25 (105)	.086 (.470)	198 (125)	.587 (.376)	114 (120)	.307 (366)

Note. Ms = millisecond measure. *D* = *D* measure. The number in parenthesis is *SD*. "Racism→Delicious" means racism IAT precedes delicious IAT. "Delicious→Racism" means delicious IAT precedes racism IAT. "C→I" means that congruent block appears before incongruent block. "I→C" means that incongruent block appears before congruent block.

We conducted some additional analyses that were not included in McFarland and Crouch (2002). A 2 (IAT Sequence: racism IAT first or second) × 2 (Task Order: congruent pairings first or second) × 2 (color: same color vs. varied color) ANOVA was conducted for the two IATs. The means and *SD*s of the IAT effects are presented in Table 3.

Delicious IAT. The sequence of the IATs did not influence *D* [M_1 = 1.17, M_2 = 1.10; $F(1, 93) = 3.09$, $p = .082$]. In the case of the millisecond measure, IAT effects were stronger when the delicious IAT preceded the racism IAT [M_1 = 544 ms, M_2 = 469 ms; $F(1, 93) = 5.92$, $p = .017$]. *D* did not depend on task order within IATs (M_1 = 1.21, M_2 = 1.16; $F(1, 93) = 2.94$, $p = .09$]. However, the effect of task order was evident for the millisecond measure [M_1 =613 ms, M_2 = 511 ms; $F(1, 93) = 11.23$, $p = .001$]. These results are consistent with the expectation of Greenwald et al. (2003) that the *D* measure would be resistant to prior experience and task order. The IAT effects in the same color condition were larger than those for the varied color condition for both the millisecond [M_1 = 555 ms, M_2 = 457 ms; $F(1, 93) = 8.95$, $p = .004$] and the *D* [M_1 = 1.18, M_2 = 1.09; $F(1, 93) = 5.30$, $p = .024$] measures.

Racism IAT. There were no effects of IAT sequence for either the millisecond [M_1 = 172 ms, M_2 = 175 ms; $F(1, 93)$ = .09 , p = .768] or the D M_1 = 0.508, M_2 = 0.561; $F(1, 93)$ = .07 , p = .799] measures. There were strong effects of task order for both the millisecond measures [M_1 = 247 ms, M_2 = 87 ms; $F(1, 93)$ = 39.28, $p = 10^{-8}$] and the D measure [M_1 = 0.710, M_2 = 0.329; $F(1, 93)$ =31.72, $p = 10^{-7}$] in that IAT effects were considerably stronger when the congruent condition preceded the incongruent condition. Thus, the D measure did not remove the effect of task order for the racism IAT. This result suggests that factors other than response speed are responsible for this order effect. Color made no difference on the millisecond measure [M_1 = 180 ms, M_2 = 168 ms; $F(1, 93)$ = 0.63, p = .428), but significant difference on D [M_1 = 0.733, M_2 = 0.456; $F(1, 93)$ = 5.10, p = .026], with the IAT effect being smaller in the different color condition.

DISCUSSION

The reanalysis and replication reveal that the IAT millisecond-difference measure is confounded by general cognitive skill that encompasses response speed and other abilities that may affect task performance. By using D, the correlations between the IAT effect and mean latencies were reduced to nonsignificance. And in our replication, based on a larger sample than those used by McFarland and Crouch (2002), the correlations between unrelated IATs also became nonsignificant. Our replication study also showed evidence of the D measure's resistance to order effects and to prior experience with IAT. These results point very clearly to the advantages of D over the conventional difference measure.

Cognitive Confounding Due to Response Speed . Research has established that a general speed factor underlies many cognitive tasks (Salthouse, 1996) and that this factor tends to influence magnitudes of treatment effects for subjects who differ in response speed. Generally, slow responding produces larger treatment effects (Brinley, 1965; Faust, Balota, Spieler, & Ferraro, 1999; Ratcliff, Spieler, & McKoon, 2000). Factors associated with response speed include *aging* (Levine, Preddy, & Thorndike, 1987; Salthouse, 1996), *intelligence* (Jensen, 1993; Levine et al., 1987; Salthouse, 1996; Vernon, 1983), and *task switching* (Meiran, Chorev, & Sapir, 2000; Salthouse, Fristoe, McGurthy, & Hambrick, 1998). The IAT involves a series of cognitive categorization tasks. Individual differences in general response speed may therefore influence the magnitude of the IAT effect. The transition from one response mapping to another taxes the ability of the participant to learn a new rule; individual differences in this ability will contribute to the response speed in the second condition and the IAT effect. Within an IAT block, the type of classification alternates in every trial. This constitutes a type of task switching, and the individual difference in the ability to switch tasks may contribute to the variance of the IAT effect. These factors can affect the individual's response speed and consequently contaminate the IAT effect. So the simple difference of the latencies across two conditions can depend on cognitive skills associated with response speed. McFarland and Crouch (2002) made this point, and our replication confirms that the IAT effect in millisecond units substantially correlates with average latency.

The D Measure. Although the difference measure in millisecond unit can be confounded by response speed, the present work provides evidence that the IAT can be scored to minimize this confound. *D* adjusts the magnitude of the difference score by dividing it by the individual latency *SD* across congruent and incongruent blocks. By using *D*, the correlations between the IAT effect and mean latencies are reduced to nonsignificance as are the correlations between unrelated IATs.

Mierke and Klauer (2003), using completely different content, reported a similar method-specific variance in the IAT effect. In their research, one IAT was used to measure an experimentally imposed novel association while another measured a preexisting association. These two IATs substantially correlated with each other when the IAT effect was measured in millisecond units. However, Mierke and Klauer reported that the *D* measure successfully removed this confounded correlation.

Still, for the McFarland and Crouch (2002) racism data reanalyzed here, *D* scores did not eliminate the cognitive confound, indicating that *D* scores may not always serve this purpose. Speculating, it may be that the cognitive confound is multifaceted, due partly to individual differences in response speed and partly to a skill of suppressing category incongruence, as McFarland and Crouch suggested. Our reanalyses make clear that *D* scores eliminate the speed of responding confound. Conceivably, however, some IATs require greater suppression skill than do others. For those that require greater suppression skill, *D* scores may be less certain to reduce the confound. Because both "delicious" and "happy" connote strong positive emotions, incongruent presentations (i.e., delicious–unhappy and not delicious–happy) may be especially affected by this skill. McFarland and Crouch found that the latencies on the incongruent presentations on this IAT were consistently the slowest of those in their study (see Tables 1 and 3 in McFarland and Crouch's article), suggesting that category incongruence is more difficult to overcome on this IAT than on many others. For that reason, the portion of the cognitive confound that is associated with suppression skill may not always be eliminated by *D* scoring.

Greenwald et al. (2003) recommended the use of *D* on the basis of analyses of large data sets. On the basis of their smaller experimental studies, Mierke and Klauer (2003) made a similar recommendation: "Even though there is currently no clear–cut account for how the new algorithms work, the convincing results obtained for the data in this paper suggest that the new scoring procedures are superior to the conventional algorithms and should be used in future research with the IAT, either instead of or in conjunction with the standard scoring procedures" (p. 1190). Both our reanalysis of the data originally reported by McFarland and Crouch (2002) and our replication of a portion of their research design reinforce these recommendations.

APPENDIX

	Exemplars
Delicious IAT	
Delicious	Candy, Yummy, Strawberry, Tasty, Cookies, Chocolate
Not delicious	Liver, Spoiled, Rancid, Turnips, Rotten, Anchovies
Happy	Joy, Laughter, Gleeful, Optimism, Merry, Cheerful, Blissful
Unhappy	Depressed, Despair, Gloom, Pessimism, Sobbing, Misery, Hopeless
Racism IAT	
European American	Heather, Nancy, Mary, Margaret, Melanie, Stephanie
African American	Latonya, Shavonn, Tashika, Ebony, Tameka, Latisha, Sharonda, Shereen
Pleasant	Friend, Cheer, Gift, Love, Vacation, Lucky, Hug, Sunshine
Unpleasant	Filth, Sickness, Accident, Pollution, Jail, Cancer, Vomit, Stink

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