A portable version of the go/no-go association task (GNAT)

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The present article describes a portable version of the go/no-go association task (GNAT) that runs on Palm Pilot and Handspring personal digital assistant (PDA) devices. The PDA version of the GNAT was modeled after a portable version of the Implicit Association Test (Dabbs, Bassett, & Dyomina, 2003) and was designed to facilitate measurement of implicit social cognition in field settings and among difficult-to-reach populations. The PDA version of the GNAT was used to assess implicit attitudes about smoking among 11 smokers and 28 nonsmokers. Support for the validity of the PDA version of the GNAT was provided by findings that smokers showed less negative implicit attitudes toward smoking, as measured by the GNAT, than did nonsmokers and that these implicit attitudes were positively correlated with self-reported smoking attitudes among both groups.

Implicit social cognition is defined as a lingering influence of previous experience on subsequent behavior that may occur outside awareness (Greenwald & Banaji, 1995). An increasing number of measures are being developed to assess such implicit social cognitions by examining reaction time (RT) rather than relying on self-report (see Fazio & Olson, 2003, for a review). A limitation of these measures is that administration typically requires a desktop computer, making field research using these techniques difficult. Portable versions of these tasks would (1) increase ecological validity by allowing for the measurement of implicit social cognition in naturalistic settings, (2) offer insight into the malleability of implicit attitudes in response to interesting real-world events, and (3) facilitate measuring implicit social cognition in groups that one might find difficult to get into laboratory settings. Dabbs, Bassett, and Dyomina (2003) recently addressed the advantage of portable measures of implicit social cognition with the development of a version of the Implicit Association Test (IAT) that runs on a Palm Pilot or Handspring Visor personal digital assistant (PDA).

The IAT (Greenwald, McGhee, & Schwartz, 1998) is the most popular of the RT measures of implicit social cognition and has been used to assess numerous psychological phenomena including prejudice (Greenwald et al., 1998), sexism (Rudman & Kilianski, 2000), romantic fantasies (Rudman & Heppen, 2003), spider phobia (de Jong, van den Hout, Rietbroek, & Huijding, 2003), weight identity (Grover, Keel, & Mitchell, 2003), and self-esteem (Greenwald & Farnham, 2000). Dabbs et al. (2003) previously described a PDA version of the IAT that would allow researchers to measure implicit social cognition in field settings. The portable version of the IAT has advantages over desktop computer administration in that it offers an opportunity to measure implicit social cognition in response to real-world events. For example, previous research using the IAT has compared implicit attitudes about alcohol among heavy and light drinkers (Wiers, van Woerden, Smulders, & de Jong, 2002). The ecological validity of such research could be enhanced by using the PDA version of the IAT to measure implicit attitudes about alcohol at venues where drinking occurs (i.e., restaurants and bars). Furthermore, the PDA version of the IAT might make it easier to measure implicit social cognition among interesting or hard to reach populations. For example, Gray, MacCulloch, Smith, Morris, and Snowden (2003), using the desktop administration of the IAT, recently assessed implicit attitudes about violence among murderers. Data collection from such rare and interesting groups might be facilitated by researchers' use of PDA administrations.

The present article describes a similar portable version of the go/no-go association task (GNAT; Nosek & Banaji, 2001) that runs on a Palm Pilot or Handspring Visor PDA. The development of the portable version of the GNAT was meant as a supplement to the portable version of the IAT

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to expand the toolbox available to researchers interested in measuring implicit social cognition in naturalistic settings. The GNAT circumvents some of the limitations of the IAT and may be better suited to addressing certain types of research questions. The differences in the two tasks are discussed below, followed by a presentation of how the portable version of the GNAT works and then the results of a sample study demonstrating the validity of the portable GNAT.

The IAT (Greenwald et al., 1998) measures implicit social cognition based on the relative ease with which participants can pair target concepts and evaluative concepts with separate responses. These authors recognized the limitation of the IAT, in that it is best suited for measuring naturally dichotomous target concepts. This limitation was further illustrated by Brendl, Markman, and Messner (2001), who argued that the IAT does not distinguish which of two target concepts drives any given effect. For example, any difference in an IAT assessing implicit racism could be a consequence of attitudes about the target concept label "White" or a consequence of attitudes about the target concept label "Black." A pro-White attitude might have very different consequences than an anti-Black attitude. Recently, Nosek and Banaji (2001) developed the GNAT. The GNAT measures the extent of mental association between a target concept (e.g., fruit) and two ends of an evaluative dimension (e.g., good and bad). In the typical desktop computer administration, the participants are required to make a response (e.g., click the mouse) if a word presented on the screen belongs to either a target category or an evaluative category, where the linkage between these categories is being assessed, and to make no response if the word belongs to neither category. This procedure is based on the signal detection assumption that greater sensitivity to the presence of a stimulus will be evidenced by greater ease of distinguishing that stimulus from background noise. Participants must pair two categories with a single response, in essence forcing them to make a single perceptual decision—does the word warrant a response (go) or not (no go)? Consequently, the greater the mental link between the categories, the more readily the participants can distinguish go words from no-go words. The GNAT has an advantage over the IAT in that it allows for assessing implicit attitudes about a single target concept. For example, Nosek and Banaji demonstrated that participants associated bugs more with bad than with good and fruit more with good than with bad. Depending on whether the participant views the target concept (e.g., fruit) as good or bad, his or her RT on a given trial may be faster or slower as a function of which evaluative concept (e.g., good or bad) is being linked with the target concept as the criterion for responding. If a participant views fruit as good, then he or she will respond faster on trials in which fruit words and good words are paired as the response criterion because the mental compatibility of these concepts will facilitate the participant's ability to produce the same response to words in either category. Furthermore, if a participant views fruit as good, then he or she will respond more slowly on trials in which fruit

words and bad words are paired as the response criterion because the mental incompatibility of these concepts will produce a Stroop-like interference for making the same response to words in either category. The GNAT circumvents the limitation of the IAT because it uses only one target concept. Therefore, any difference in RT offers an index of the relative mental linkage between the target concept and the two evaluative concepts.

Hardware and Software

PDAs have been used in a variety of field research projects, such as to record physical fitness levels of people exercising in a gymnasium (Spain, Phipps, Rogers, & Chaparro, 2001) and to measure alcohol consumption among attendees at a public festival (Fletcher, Erickson, Toomey, & Wagenaar, 2003), to measure daily fluctuations in mood (Barrett & Barrett, 2001; Tseng, Tiplady, Macleod, & Wright, 1998), and to measure reactions to medical treatments (Whalen, Jamner, Henker, & Delfino, 2001). PDAs are relatively inexpensive, with basic models costing about \$150, and many potential research participants are familiar with them.

The portable version of the GNAT, modeled after the PDA version of the IAT, offers an advantage over desktop computer administration because it can be used outside the laboratory. It was designed for use with Palm Pilot and Handspring PDAs, both of which use the Palm OS operating system, and will not run on devices that use other operating systems. The program was written in C++ and compiled into Palm OS. Using a PDA synchronization conduit, information can be transferred between the PDA and a host Macintosh or PC computer. By performing a HotSync operation, stimuli can be transferred from the host computer to the PDA, and responses can be transferred from the PDA to the host computer.

Input File

The input file contains lines consisting of a target category label, an evaluative category label, three target exemplars, three evaluative exemplars, and six distractor words. Each input line produces a block of 24 trials. The category and evaluative labels are visible at the top of the screen for the duration of a block of trials. A GNAT score requires a minimum of two input lines. Within each block of trials, each of the 12 stimulus words is presented twice, for a total of 24 presentations. Stimuli are presented in one of 20 predetermined random orders, with the restriction that words representing the same construct cannot appear more than three times consecutively. Each word remains on the screen until either the participant taps the screen with the stylus or a preprogrammed amount of time elapses. Just as with the desktop computer version, the PDA version allows the experimenter to adjust how long stimuli remain on the screen in the absence of a response and to adjust the interstimulus interval.

Administrator Options

The participants initiate the program by tapping the GNAT icon on the palm home screen. No other PDA ap-

plications can be running when the GNAT program is started, and no other applications can be accessed until the GNAT program is exited. Once the GNAT application has been launched, the experimenter may choose from several administrator options by performing a power swipe and entering a password. From the administrator screen, one can choose up to three times per day for the PDA to sound an alarm and initiate the GNAT application. This feature could be used for collecting data at regular intervals over extended periods of time from the same group of subjects. The alarm signals the participants that it is time to complete the GNAT tests. In addition, the administrator screen allows the user to edit the stimuli and to view all responses stored in the PDA since the last HotSync operation. Furthermore, the administrator can alter the interstimulus interval and stimulus duration from this screen by entering a numeric value in the appropriate blank. This option was designed to parallel desktop administrations of the GNAT that have utilized varying stimulus durations (Nosek & Banaji, 2001). The researcher has the flexibility to alter the stimulus duration on different trials using the same stimulus words, without having to upload a new version of the application using the HotSync operation.

Running the Application

The program is initiated by tapping the GNAT icon on the palm home screen. The program presents a screen labeled Go/No-go Association Task and indicates which test follows “(Test 1 of n)” and instructs participants to enter their initials and press Continue (see Figure 1A). The program will not advance to the next screen until the user enters his or her initials using the PDA keyboard. The next screen presents three buttons labeled Begin Test, Instructions, and Exit (see Figure 1B). Tapping the Exit button returns the user to the PDA’s home screen. Tapping the Instructions button presents a sample test screen but does not present any stimuli. The sample screen shows the two target category labels in all capital letters and the three examples of each category in lowercase letters (see Figure 1C). In bold letters at the top of the screen, participants are instructed to examine the concepts below and press continue. When the user taps Continue, the next screen is presented; on it, the category labels, but not the exemplars, remain visible at the top of the screen (see Figure 1D). The following instructions also appear in the center of the screen: “If words appear that represent either of the concepts, then press the screen. If other words ap-

Figure 1. Typical screens a participant sees during a PDA GNAT testing session.

pear, then don't press." Tapping Continue on this screen returns the user to the screen with the menu options of Begin Test, Instructions, and Exit. Choosing the Begin Test option leads to the same two screens described in the instructions option. On the first screen (Figure 1C), the user is presented with the two category labels to be used in the test, as well as the three exemplars for each category. On the second screen (Figure 1D), labeled Test 1, the user sees the category labels at the top of the screen and reads the instructions for the test. Tapping Continue on this screen initiates the test, and 24 word stimuli will be presented one at a time in the center of the screen from 1 of 20 predetermined random orders. Each word stays visible on the screen until the user makes a response or a preset time limit elapses (see Figure 1E). The device produces a beep following any commission or omission errors made during a test. When all 24 stimuli have been presented, the program presents a screen labeled GNAT Test 2, with the instructions, "When ready to start press continue. Then examine the words on the two sides of the screen." From here, users are taken to the screen presenting the category labels and exemplars for the second test. Note, the target category label and exemplars will be the same as those from Test 1, but the evaluative category will now be different. This process will continue until the user has performed the task for all sets of stimuli indicated by the input file. Upon completion of the final test, users are presented with a screen displaying the average RT and the percentage of correct responses they made for each test. When the user taps Continue on this screen, a message reading "Thank You. Tests Over" appears, and the user is returned to the first test screen (see Figure 1F).

Timing Precision

The highest degree of timing precision on a Palm OS device is represented by a "tick." A tick is equal to 10 msec. In the PDA GNAT solution, timing is critical, so all ordering and randomizing calculations are performed before the test is started, and all results are tabulated and written to the PDA's memory after each test is completed. During the testing session, the application has been optimized to perform the minimum amount of work possible by simply displaying the words on the screen and then responding to taps from the participants. In sum, the steps taken by the PDA throughout the execution of the application are these: (1) start the program; (2) open the prompt

database to read stimuli; (3) count, randomize, and store in memory the stimuli and response values; (4) capture the participant's initials; (5) display all stimuli and possible responses to the participant; (6) wait for user to begin the test; (7) show empty screen for 1 sec (100 ticks); (8) play beep sound; (9) record "start palm tick" value; (10) repeat for each stimulus/response; (11) show n th stimulus and possible responses; (12) poll for a pen down on screen; (13) record response tick value; (14) move to next stimulus; (15) when test is completed, record timing, responses, and correct/incorrect values in response database. The returned RT values will be in 10-msec resolution, with an estimated ± 10 -msec margin of error.

Output File

The PDA records participants' RTs and the correctness of responses. A sample data output file is presented in Figure 2. Each GNAT task produces tab-delimited data for each block of trials containing the participant's identification number, the two category labels used for that block of trials, the date and time the task was performed, the preprogrammed time in milliseconds that the stimuli were allowed to stay on the screen in the absence of a response, a number indicating which of 20 predetermined random orders was used to present the stimuli, 24 RT scores, and 24 correctness scores (coded as 1 = *correct* and 0 = *incorrect*). Note that the output file does not distinguish between commission errors (responding to distractors) and omission errors (failures to respond to target or evaluative category words). This distinction is not necessary for RT scoring because the mean RT is calculated only for correct responses. However, those wishing to distinguish between commission and omission errors for the purpose of signal detection (d') scoring can do so by looking at both the correctness and RT variables. All errors (coded 0) with an RT of less than the preprogrammed stimulus duration are commission errors. All errors (coded 0) with RTs equal to the preprogrammed stimulus duration are omission errors.

SAMPLE STUDY

To test the validity of the PDA version of the GNAT, explicit and GNAT measures of attitudes about smoking were collected from both smokers and nonsmokers. We expected to demonstrate the convergent validity of

003	Smoking		Good	11/19/2002	18:42	1400	19	1400	1160	1400
810	1400	1400	740	1400	680	1400	1400	990	1400	810
1160	890	1400	580	970	1400	1400	1400	1	1	1
1	1	1	1	0	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1
003	Smoking		Bad	11/19/2002	18:43	1400	15	1030	1400	1400
1120	1400	1400	920	820	1400	920	1400	620	900	1400
1400	1400	650	780	1400	760	1400	650	1	1	1
1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1

Figure 2. Sample data output file.

the PDA version of the GNAT by showing that GNAT measures of implicit smoking attitudes were related to explicit measures and differed between smokers and nonsmokers.

Method

Participants. Thirty-nine participants were stopped at various locations around the campus of a large urban university and invited to participate. No incentive or enticement was offered for their participation.

Procedure. Prior to data collection, the researchers submitted a project description to the Institutional Review Board at Georgia State University and obtained approval to collect anonymous survey data. Researchers approached groups of people at various campus locations where they were congregated and asked if anyone would be interested in participating in a study on attitudes about smoking being conducted by the psychology department. Participants were asked to complete a brief questionnaire assessing their smoking habits and to rate their explicit attitudes toward smoking on a nine-point Likert-type scale (1 = *extremely unfavorable* and 9 = *extremely favorable*).

In addition, participants performed two tasks on the PDA version of the GNAT. The participants held the PDA in their nondominant hand and with their dominant hand used a stylus to tap the PDA screen. After starting the GNAT program by tapping the GNAT icon on the PDA desktop, participants used the PDA keyboard to enter a three-digit number that appeared on the attitudes-about-smoking questionnaire they had previously completed. This number, which was recorded by the GNAT application in the output file, enabled researchers to link participants' questionnaire responses to their PDA GNAT scores. After entering the three-digit identifier in the initial screen, participants were asked to read through the instruction screens. After reading through the instruction screens, participants were instructed to start the testing session by tapping the Begin Test button. On the first task, participants were required to tap the PDA screen if a word belonged to either the Smoking or the Good category. The exemplars for the category Smoking were smoking, tobacco, and cigarette. The exemplars for the category Good were good, great, and wonderful. The distractor words were table, rug, square, copper, meter, and periodical. On the second task, participants were required to tap the PDA screen if a word belonged to the Smoking or the Bad category. The exemplars for the category Smoking were smoking, tobacco, and cigarette. The exemplars for the category Bad were bad, awful, and terrible. The distractor words were table, rug, square, copper, meter, and periodical. For both tasks, the stimulus duration was set at 1,400 msec, and the interstimulus interval was set at 40 msec.

Results

The mean RT for correct responses was calculated for each trial. RTs for incorrect responses were not included, and responses to items faster than 400 msec were excluded. Nonsmokers responded faster when pairing Smoking words and Bad words with a response (mean = 727 msec) than when pairing Smoking words and Good words with a response (mean = 781 msec). In contrast, smokers responded faster when pairing Smoking words and Good words with a response (mean = 727 msec) than when pairing Smoking words and Bad words with a response (mean = 745 msec). A GNAT measure of implicit attitudes about smoking was created by subtracting the mean RT when responding to the categories Smoking and Good from the mean RT when responding to the categories Smoking and Bad, with larger values being

indicative of more positive attitudes toward smoking. Smokers ($n = 11$) showed more positive implicit attitudes toward smoking on the GNAT score than did nonsmokers ($n = 28$) [$t(35) = 2.1, p < .05$], with means of 18 msec and -54 msec, respectively. Similarly, smokers explicitly rated smoking more favorably than did nonsmokers [$t(35) = 3.5, p < .01$], with means of 3.5 sec and 1.7 msec, respectively. Furthermore, the GNAT score was significantly positively correlated with explicit ratings of smoking [$r(37) = .31, p < .05$], such that more favorable implicit attitudes were associated with more favorable explicit attitudes.

DISCUSSION

The finding that scores on the PDA GNAT measure of implicit attitudes about smoking distinguished between smokers and nonsmokers supports the convergent validity of the PDA administration of the GNAT for measuring implicit social cognition in nonlaboratory settings. These findings are somewhat inconsistent with previous findings that both smokers and nonsmokers held negative implicit attitudes about smoking (Swanson, Rudman, & Greenwald, 2001). Using the IAT, these authors concluded that smokers and nonsmokers implicitly associated smoking more with bad than with good. However, because there is no natural opposite of smoking, this effect depended on the comparison category chosen (i.e., sweets). Therefore, this finding may have reflected a methodological limitation. An alternate interpretation to Swanson et al.'s conclusion that smokers implicitly disliked smoking as much as nonsmokers did is that both groups implicitly preferred sweets more than smoking to the same extent. The present data, using the GNAT, did show a difference in the implicit attitudes of smokers and nonsmokers, suggesting that nonsmokers viewed smoking more negatively than did smokers. However, the difference reflects that smokers responded with about equal speed when pairing smoking with good and bad, but nonsmokers responded faster when pairing smoking with bad than when pairing smoking with good. The small sample size in the present study warrants caution about reinterpreting previous findings about smokers' overall implicit attitudes about smoking. However, the goal of the present study was only to validate the portable version of the GNAT. Smoking was chosen as the target concept because it was mentioned in Nosek and Banaji's (2001) description of the GNAT as an example of a nondichotomous concept better suited to measurement using the GNAT than the IAT. In addition to the group differences reported here, the validity of the portable version of the GNAT is further substantiated by the finding that implicit attitudes toward smoking (operationalized as the difference in RT between responses when smoking and good words were the response criteria and when smoking and bad words were the response criteria) were related to self-reported attitudes about smoking.

The PDA version of the GNAT is not meant as a replacement for the PDA version of the IAT but rather as a means of allowing researchers interested in field research

on implicit social cognition to choose the technique best suited to their problem of interest. Nosek and Banaji (2001) pointed out that, whereas the IAT is well suited for evaluating implicit social cognition regarding naturally dichotomous concepts (e.g., Black–White), the GNAT is better suited for measuring implicit social cognition about a single concept (e.g., smoking) for which there is no natural comparison concept. Naturally dichotomous concepts may be measured with the IAT, whereas non-dichotomous concepts may be best measured using the GNAT. Researchers can choose which measure is best suited to their unique research question but now have the opportunity to use either the IAT or the GNAT in situations where desktop computer administrations would be untenable.

Although the findings from the present study suggest the feasibility of measuring implicit social cognition in field settings, several questions about such PDA administration remain unanswered. The PDA device can potentially record response times with .10-msec precision, but there is no evidence from the present study to verify its timing accuracy. RT accuracy is likely influenced by screen polling and refresh times, which vary across devices. The length of word stimuli may also introduce error, because longer words increase screen draw time, which may, in turn, affect timing accuracy. Future research is needed to clarify these issues.

A particularly fruitful avenue for future research would be to make direct comparisons between desktop computer and PDA administrations of the GNAT. Although these comparisons could be conducted using the current PDA GNAT program, some modifications to the application might facilitate direct comparison of the different administrations. The PDA GNAT described in the present study was designed to use RT scoring, whereas the typical desktop administration (Nosek & Banaji, 2001) uses signal detection scoring. Data from the current PDA GNAT can be scored using signal detection, but that process involves a somewhat convoluted set of steps whereby hits and false alarms can be determined by consulting two scores (the correctness score and the RT score) in the output file. It would be desirable to develop future versions of the PDA GNAT that directly recorded hits and false alarms in the output file. In addition to the scoring difference, the PDA and desktop versions of the GNAT also utilize different numbers of exemplar words in each category. Nosek and Banaji used 24 exemplars of each category in their desktop administration of the GNAT, whereas the present authors used only 3 exemplars of each category in the PDA administration. The authors know of no research directly assessing variation in GNAT effects as a function of the number of exemplars used; however, Greenwald and Nosek (2001) cited evidence that equivalent IAT effects are obtained when using 25 and 5 category exemplars. Even though implicit social cognition may be measured using a few category exemplars, future research should examine the effect of altering the number of exemplars in both the desktop and PDA administrations of the GNAT

and should directly compare PDA and desktop administrations of the GNAT using the same number of exemplars. Because the PDA GNAT application described in this article limits researchers to three category exemplars, it would be desirable to develop future versions of the PDA GNAT that allow researchers to vary the number of exemplars.

Even if the PDA application is demonstrated to record RTs accurately and to produce measures of implicit social cognition consistent with measures obtained from desktop computer administration, there remains the problem of errors introduced by the testing environment. Measures garnered in field settings are more prone to error than are measures taken in laboratory settings because the researcher lacks control over the testing environment. However, laboratory research is still needed to demonstrate that, in the same testing conditions, PDA administrations and desktop computer administrations measure implicit social cognition equivalently. The results of the present study are interesting because they suggest that effects on measures of implicit social cognition, like the GNAT, may be so robust that they can be detected even in settings where error variance is likely high. The authors hope that the research presented here stimulates interest in developing other PDA applications to measure implicit social cognition.

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