

Brain potentials show rapid activation of implicit attitudes towards young and old people

Citation for published version (APA):

van der Lugt, A. H., Banfield, J. F., Osinsky, R., & Munte, T. F. (2012). Brain potentials show rapid activation of implicit attitudes towards young and old people. *Brain Research*, 1429(6), 98-105. <https://doi.org/10.1016/j.brainres.2011.10.032>

Document status and date:

Published: 06/01/2012

DOI:

[10.1016/j.brainres.2011.10.032](https://doi.org/10.1016/j.brainres.2011.10.032)

Document Version:

Publisher's PDF, also known as Version of record

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Research Report

Brain potentials show rapid activation of implicit attitudes towards young and old people

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ARTICLE INFO

Article history:

Accepted 19 October 2011

Available online 25 October 2011

Keywords:

Go/NoGo

ERP

Stereotype

Implicit association

ABSTRACT

While previous behavioural research suggests that attitudes, for example towards elderly people, may be activated automatically, this type of research does not provide information about the detailed time-course of such processing in the brain. We investigated the impact of age related attitude information in a Go/NoGo association task that paired photographs of elderly or young faces with positive or negative words. Event related brain potentials showed an N200 (NoGo) component, which appeared earlier in runs which required similar responses for congruent stimulus pairings (e.g. respond to pictures of elderly faces or negative words) than for incongruent pairings (e.g. respond to elderly faces or positive words). As information processing leading to a certain attitude must precede differential brain activity according to the congruence of the paired words and faces, we show that this type of information is activated almost immediately following the structural encoding of the face, between 170 and 230 ms after onset of the face.

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“Will you still need me,
will you still feed me,
when I’m sixty-four?”
John Lennon/Paul McCartney

Paul McCartney has already passed his hallmark 64th year, yet attitudes towards the elderly appear not to have changed much since these lines were penned. Despite the fact that each of us knows that ageing is inevitable, negative attitudes towards the elderly are still prevalent in our society (e.g., Butler, 1986; Cuddy et al., 2005). Attitudes are functional in that they quickly allow us to assess whether something or someone is good or bad or to be approached or avoided (e.g., Maio and Olson, 1995). It has been argued that we make rapid and even automatic evaluations of people, objects or groups (e.g., Fazio, 1986; Greenwald et al., 1998;

Wittenbrink et al., 1997). For example, Fazio (1986) showed that, when presented with a negatively valenced word as a prime, e.g. *cockroach*, subjects were subsequently faster to respond to negatively valenced adjectives (e.g. *disgusting*) as compared to positively valenced adjectives (e.g., *appealing*), which appeared 300 ms later. This, they argued, was because the word *cockroach* automatically activated a negative evaluation (as the stimulus onset asynchrony was so brief). Initial evaluative assumptions appear to occur automatically and outside of conscious awareness (Brewer, 1988; Devine, 1989; Greenwald and Banaji, 1995). Since this kind of work appeared, other techniques have been developed to measure different aspects of attitude activation.

As a relatively new measure of implicit social cognition, the Go/NoGo association task (Nosek and Banaji, 2001) (GNAT, see Fig. 1), can be used to measure underlying

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Task Instruction: Press only when old or good

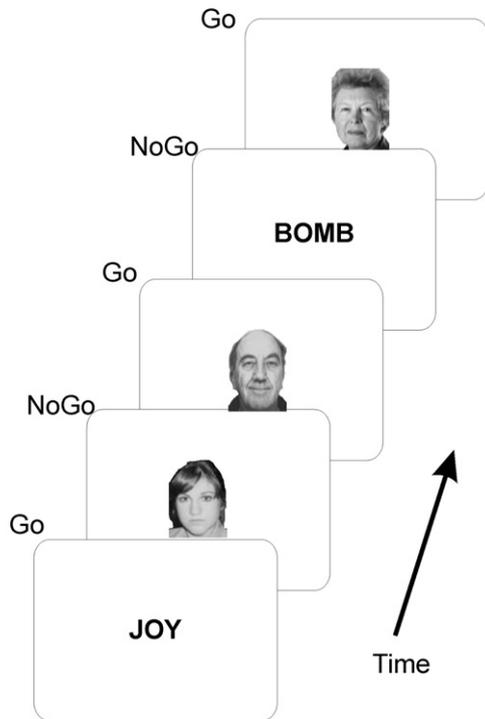


Fig. 1 – Go-NoGo association task. The subject views a random series of stimuli comprising faces (elderly and young) and words (positive and negative) with the task to press a button as fast as possible for one face category (in this example elderly) and one word category (in this example positive), while withholding responses for the other categories.

associations between categories (e.g., faces of elderly or young people) and either pole of an evaluative dimension (e.g., positive or negative words). In the GNAT, participants are required to either make a one-handed response or to withhold their response to different stimuli presented consecutively, depending on the instructions given. Go-responses to incongruent pairings (e.g. press for elderly people or positive words) typically result in slower response-times (RTs) as compared to congruent pairings (e.g. elderly people and negative words). Differences in response times (RTs) can thus be taken as an index of the strength of an individual's automatic associations, with a bigger difference indicating a stronger implicit attitude. The GNAT and the conceptually similar Implicit Association Task (IAT) (Greenwald et al., 1998), have been used successfully to investigate implicit attitudes towards race, gender and body-weight (Grover et al., 2002; Nosek and Banaji, 2001), among others. Another way to assess implicit attitudes to social stimuli is the use of physiological measures. For example, event-related brain potentials (ERPs) and functional magnetic resonance imaging (fMRI) have been used to assess differential neural activity evoked by faces of the same race and another race as the observer's (e.g., Caldara et al., 2003, 2004; Cunningham et al., 2004; Golby et al., 2001; Hart et al., 2000; He et al., 2009; Ito and Urland,

2003, 2005; Ito et al., 2004; James et al., 2001; Lieberman et al., 2005; Phelps et al., 2000; Willadsen-Jensen and Ito, 2006). Indeed, such differential processing has been reported in the majority of the studies. For example, fMRI studies revealed greater activity of the amygdala for Black vs. White faces in white participants, which by inference from animal work on this structure was interpreted as indicative of negative emotions associated with Black faces (Cunningham et al., 2004; Hart et al., 2000). With regard to ERPs, researchers have taken advantage of the presence of several face-sensitive components that appear in temporal succession and have asked which of these showed sensitivity to race, thereby trying to localize the effect of race in the cognitive processing cascade. For example, Ito and Urland (2005) and Herrmann et al. (2007) investigated the effect of race on the face-sensitive temporooccipital N170 component, which is supposed to reflect the structural encoding of facial features. Whereas both studies reported an effect of race on N170 amplitude, the effect was opposite (Ito and Urland, 2005: same > other race; Herrmann et al., 2007: other > same race). Nevertheless, these studies have shown that features of a face that are known to be associated with implicit attitudes, such as race, are processed differentially in the brain at a very early processing stage. To link such differences with measures of implicit attitude, He et al. (2009) assessed ERPs and, in a separate session, implicit attitudes towards race using the IAT. With regard to ERPs, Black faces evoked a larger frontal positivity around 170 ms and White faces were associated with a larger negativity at about 250 ms and both of these differences correlated significantly with participants' IAT scores.

To establish a more direct link between brain potentials and behavioural measures of implicit attitude, we recorded ERPs while participants were engaged in a GNAT designed to capture their implicit attitudes about elderly and young people. In combination with a Go/NoGo task, ERPs may provide an excellent early index of the time-course of evaluative associations, as previous studies have revealed a phasic negativity over the frontal scalp (Pfefferbaum et al., 1985; Thorpe et al., 1996) for NoGo- relative to Go-trials, which has been labelled "N200" or "NoGo component" (Rodriguez-Fornells et al., 2002; Schmitt et al., 2000, 2001). The latency of the N200 has been interpreted as an index of the time at which information in favour of the suppression, as opposed to the initiation, of a response becomes available. Imaging work has suggested that a neural network including left prefrontal cortex, supplementary motor area and left middle prefrontal cortex is implicated in such cognitive control mechanisms (Garavan et al., 1999; Konishi et al., 1998; Rodriguez-Fornells et al., 2005).

In a previous study (Banfield et al., 2006), we employed ERPs in a GNAT that paired words from one of two taxonomic categories (fruit/bugs) with either pole of an evaluative dimension (good/bad). Within a given block Go responses were assigned to one of the categories and one evaluative dimension. ERPs showed the expected increased frontal N200 to NoGo as compared to Go responses. Critically, NoGo minus Go difference waves showed that the N200 effect was delayed in trials within incongruent blocks (as defined by our expectations about implicit associations of the participants, e.g. "Press if a bug word or a good word") as compared to trials within congruent blocks (e.g., "Press if a bug word or a bad

word”). The timing of the incongruity effect revealed that associative information is available to the social perceiver at approximately 250 ms after seeing a fruit or a bug word. In the present investigation, we sought to replicate and extend this finding by exposing participants to pictures of young and elderly faces and words from either pole of the good/bad evaluative dimension. On the basis of our earlier study (Banfield et al., 2006), we expected a delay of the N200 NoGo-component in blocks with incongruent pairings (e.g., “Press if old face or good word”). By comparison of the timing of this effect with the timing of the face-selective ERP components, our design further allowed us to assess whether implicit associations occur rather early or late with regard to the structural encoding of faces.

1. Results

1.1. Behavioural results

Participants were instructed to respond to certain stimuli and to withhold responses to others. Two conditions were congruent with existing attitudes about the elderly held by most young people (press if elderly or negative, press if young or positive), while the other two were incongruent (press if elderly or positive, press if young or negative). Participants made only very few errors (1.5% false alarms, 1.1% misses overall, 1% false alarms, and 0.9% misses on the faces, with no differences between trials in congruent and incongruent blocks).

Reaction times were analyzed by analysis of variance (ANOVA). Overall, as expected, participants responded faster to trials in congruent blocks (630 ms, $SD=96$) than to trials in incongruent blocks (675 ms, $SD=96$, $F(1,15)=39.86$, $p<0.001$). There was also a main effect of stimulus type ($F(1,15)=26.96$, $p<0.001$) with faster RTs to faces (623 ms, $SD=84$) than to words (684 ms, $SD=108$).

To further investigate differences between the processing of young faces and old faces and between good words and bad words, two separate ANOVAs were calculated for these two types of stimuli. The post hoc analyses for the faces showed that responses to old faces were significantly faster (mean=606 ms, $SD=88$) than responses to young faces (mean=638 ms, $SD=88$, $F(1,15)=17.58$, $p<0.001$). Again, there was also a significant main effect of congruency, with faces in congruent conditions (mean=608 ms, $SD=92$) yielding faster responses than faces in incongruent conditions (mean=636 ms, $SD=80$, $F(1,15)=18.34$, $p<0.001$). In addition, a significant interaction of face category and congruency ($F(1,15)=6.54$, $p<0.05$) revealed that the congruency effect was bigger for old faces than for young faces (Fig. 2A). Similar analyses for the words revealed that responses to positive words (mean=696 ms, $SD=112$) were slower than responses to negative words (mean=672 ms, $SD=108$, $F(1,15)=11.83$, $p<0.01$). Once more, there was also a significant main effect of congruency, with words in congruent conditions (mean=653 ms, $SD=108$) yielding faster responses than words in incongruent conditions (mean=715 ms, $SEM=28$; $F(1,15)=22.1$, $p<0.001$). Finally, a significant interaction ($F(1,15)=6.54$, $p<0.05$) reflected a bigger congruency effect for positive words than for negative words (Fig. 2B).

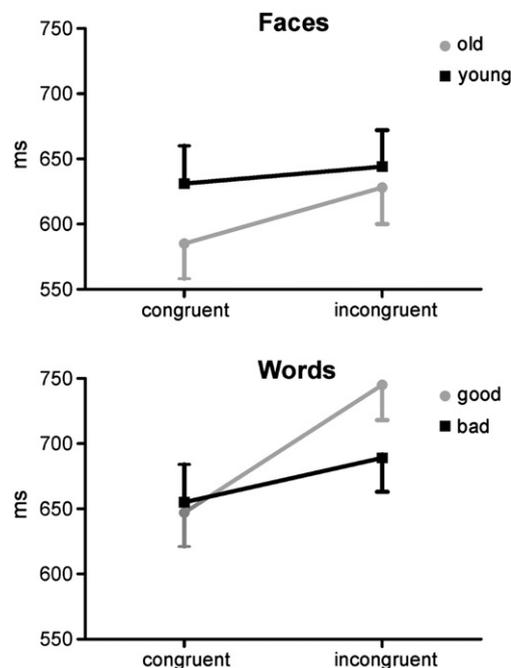


Fig. 2 – Upper panel: Average reaction times for both types of faces (young and old) in congruent and incongruent blocks. Lower panel: Average reaction times for both types of words (good and bad) in congruent and incongruent blocks.

1.2. Electrophysiological results

Brain potentials for the face stimuli (Fig. 3A) showed a typical frontal difference between NoGo and Go-trials with the former showing a more negative response from approximately 200 ms onwards which resulted in a phasic negativity in the NoGo-minus-Go difference wave which had a midfrontal distribution (Fig. 3B). This effect difference was quantified by a mean amplitude measure (time-window 200–400 ms, electrodes Fz and Cz). An ANOVA with factors response-type (Go vs. Nogo), congruency (incongruent vs. congruent) and electrode-site (Fz and Cz) revealed a highly significant main effect for response-type ($F(1,15)=10.77$, $p<0.005$). Neither the main effect of congruency ($F(1,15)=2.31$) nor the interaction of response-type by congruency ($F(1,15)=1.89$) became significant in this amplitude analysis.

This NoGo activity can be isolated by computing the NoGo minus Go difference-waves (Fig. 3B). Importantly, this difference occurred about 50 ms earlier for face stimuli that required the same response as attitude congruent words (i.e. elderly faces/negative words; young faces/positive words). The peak and onset of the N200 effect is earlier for the congruent condition than for the incongruent condition shown by sequential t-tests on the mean amplitude (midfrontal site) in a 40 ms running time-window against zero (step-size 8 ms) (Schmitt et al., 2000, 2001). The onset was defined as the first window where the mean amplitude was significantly below zero ($p<.01$). The N200 effect had an earlier onset in the congruent condition (232 ms) as compared to the incongruent condition (286 ms). This onset difference was corroborated by determining the time-point by which the area under the

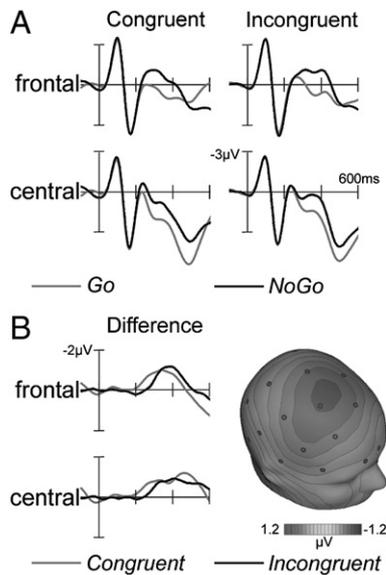


Fig. 3 – A: Group average brain responses for two midline electrodes elicited on Go and NoGo trials in congruent and incongruent conditions for faces. Both conditions are associated with a more negative waveform for the NoGo trials, i.e. an N200 effect. **B:** NoGo–Go difference waves for faces. On the right a spline interpolated voltage map illustrates the anterior topography of the N200 (congruent condition at 276 ms).

curve (time-window 100–500 ms) had reached 15% using a jackknife-based method (Miller et al., 1998) (congruent: 268 ms, incongruent: 328 ms; $t_{(15)}=2.28$, $p=0.037$). Moreover, the mean amplitude between 250 and 300 ms (left, right and mid-frontal sites) was significantly different between congruent and incongruent trials ($F(1,15)=6.02$, $p=0.026$).

Thus, ERPs show that congruent and incongruent NoGo minus Go difference waves differ as early as 232 ms (while RTs for Go trials only show differences only 400 ms later). As follows from previous work on the N200 (Rodríguez-Fornells et al., 2005; Schmitt et al., 2000, 2001), the onset of the differential brain activity can be taken as an upper limit of the time at which this type of attitude information becomes available. At this point, the faces must have been categorized in order for the Go/NoGo decision to have been made, and therefore such associations must act at this very early level of neural processing.

To investigate congruency effects we also calculated difference waves for incongruent minus congruent trials separately for Go and NoGo trials (Fig. 4). These difference waves show an early negativity on Go trials and an early positivity on NoGo trials followed by a larger negativity on NoGo trials vs. Go trials. Mean amplitude in two time windows was calculated and a 2 (Time window: 150–300 ms, 350–500 ms) \times 2 (Trial type: Go, NoGo) \times 3 (Electrode: left, right, mid-frontal) analysis of variance revealed an effect of time window ($F(1,15)=5.77$, $p=0.029$) reflecting the increased overall negativity in the later time-window. Moreover, Go trials were more negative than NoGo trials in the early ($-0.33 \mu\text{V}$ vs. $0.18 \mu\text{V}$), and more positive in the later time-window ($-0.21 \mu\text{V}$ vs. $-0.76 \mu\text{V}$, interaction time window by trial type, $F(1,15)=8.1$, $p=0.012$),

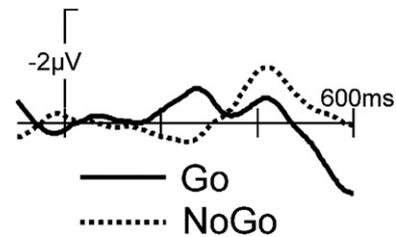


Fig. 4 – Incongruent–congruent difference waves (shown: midfrontal site).

indicating that in the NoGo trials an initial tendency to respond in the direction of the existing association (suggesting a Go response) had to be overcome. To further follow up this effect, we tested the mean amplitude in the 150–300 ms time window against zero mean. This comparison was marginally significant for the negativity seen in the Go trials ($t(15)=2.03$, $p=0.06$) but non-significant for the positivity seen in the NoGo trials ($t(15)=1.65$). When the time window was restricted to 200–250 ms, the positivity in the NoGo trials became marginally significant ($t(15)=1.95$, $p=0.07$).

A relative phasic negativity with peak latency of about 170 ms is observed with a maximum at posterior temporal sites (Fig. 5). This so-called “N170 component” has been shown to be related to the structural encoding of faces (Bentin and Deouell, 2000; Bentin et al., 1996; George et al., 1996; Schweinberger et al., 2002) and is apparently generated in the inferior temporal and fusiform gyri (Linkenhaer-Hansen et al., 1998) which harbour the fusiform face area (Gauthier et al., 2000; Kanwisher et al., 1997). A mean amplitude measure (150–190 ms, electrodes T5 and T6) was taken and entered into a response-type by congruency by hemisphere ANOVA, which revealed neither significant main effects of these factors nor an interaction.

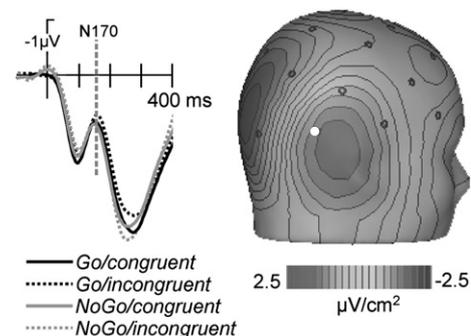


Fig. 5 – Brain potentials from a right posterior scalp site (P8; position marked by a white spot on the right) show a negative going deflection at about 170 ms for all face stimuli. A current source density map (right) identifies this deflection as the “N170” component emanating from inferior temporal cortex, which has been shown previously (Bentin et al., 2002; Linkenhaer-Hansen et al., 1998; Schweinberger et al., 2002) to index structural encoding of faces.

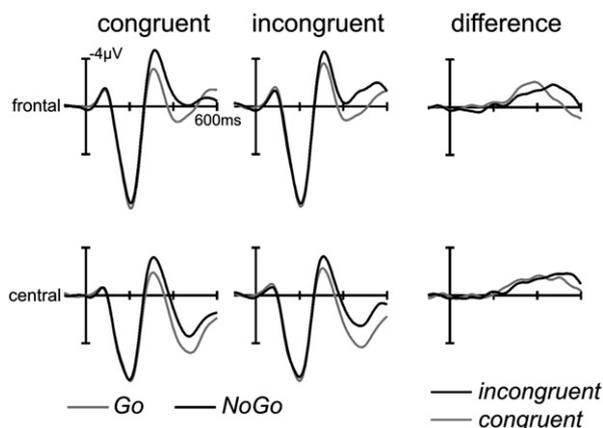


Fig. 6 – Left two columns: Group average brain responses for two midline electrodes elicited on Go and NoGo trials in congruent and incongruent conditions for words. Both conditions are associated with a more negative waveform for the NoGo trials, i.e. an N200 effect. Rightmost column: NoGo–Go difference waves for words. Occurred.

Finally, we also looked at the brain potentials for the words (Fig. 6) and carried out similar analyses as for the faces (see above). For words, NoGo-trials also showed a more negative frontal response from approximately 280 ms onwards, however, no latency differences between congruent and incongruent trials are apparent from the difference waves. In fact, neither the running t-test, nor the fractional area latency analyses yielded a congruency effect for the onset of this N200 effect.

2. Discussion

The current data indicate that implicit attitude information about age as derived from a person's face becomes available sometime between 170 ms, the lower bound for the beginning of structural encoding of the face indexed by the face specific N170 component, and 232 ms, the time-point at which the NoGo/Go difference waves begin to differ for incongruent and congruent conditions. This differential N200 effect provides an upper estimate for when attitude information must have become available (see Rodriguez-Fornells et al., 2002, 2005; Schmitt et al., 2000, 2001, for a similar logic in implicit language production tasks). This finding is of crucial importance, as it provides empirical support for the notion that such associations become available almost instantaneously upon encountering another person.¹ While the fact that these processes appear to occur in the time-window 170 ms to 230 ms does not guarantee automaticity, it would seem to strongly favor such an interpretation.

This finding is consistent with the body of behavioural work outlined in the introduction which suggests that attitude information is automatically activated (Fazio, 1986; Greenwald et al., 1998; Wittenbrink et al., 1997). These studies

rely on using short stimulus onset asynchronies between the presentation of the prime and the target words in order to look at automatic evaluation (the idea being that participants do not have time for strategic or controlled processing), or the subliminal activation of the prime words (e.g., Wittenbrink et al., 1997) and a subsequent analysis of the time taken (RT) for the subjects to respond to the target stimulus (e.g. in a lexical decision task). Both the IAT and the GNAT work in a slightly different way. IAT and GNAT effects are thought to be automatic in the sense that they are thought to measure attitudes that may exist outside conscious awareness and control (Greenwald and Banaji, 1995). Rather than assessing spontaneous evaluation of a given stimulus, these techniques assess the strength of association between the target category and an attribute dimension (in this case evaluative) by measuring response latencies in conditions where the target and attribute are either congruent or incongruent. However, as differences in response latencies tend to appear in the region of 600–700 ms, it is impossible to tell from these behavioural studies alone exactly when such associative information becomes available.

A number of previous ERP studies have tried to assess if and when information typically associated with implicit attitudes or stereotypes, in particular race, is processed by the brain. In a series of studies, Ito and colleagues (Ito and Urland, 2003, 2005; Ito et al., 2004) found that, in Caucasian participants, faces of black persons were associated with higher amplitudes of the N100 and P200 components, whereas faces of white persons led to a larger amplitude of the subsequent frontal N200. It has been suggested that the early amplitude modulations of the N100 and P200 reflect attention capture by faces from another race (Ito and Urland, 2003, 2005; Ito et al., 2004; Willadsen-Jensen and Ito, 2006), which is subsequently redirected to same race faces (indexed by the frontal N200). Obviously, while suggestive of early processing differences between same and other race face stimuli, these results cannot speak to the time at which implicit attitudes become available. Also, it has to be kept in mind that faces of black or white persons by necessity have some physical differences that may be reflected in early exogenously driven ERP components. A tighter link between ERP changes between same and other race face stimuli was recently established by He et al. (2009). These authors found ERP differences between faces of black and white people as well as between Asian and white people. Interestingly, black/white ERP differences as early as 172 ms were correlated with implicit attitudes as derived from an IAT. By contrast, the earliest Asian/white ERP difference which correlated with an Asian-IAT was found at 480 ms.

The results of the present experiment establish the time-point at which implicit associations are available to the brain in a more direct manner. They are consistent with previous work on the N200-“NoGo”-component (Schmitt et al., 2000, 2001; Rodriguez-Fornells et al., 2002, 2005; Banfield et al., 2006), and with our hypotheses. As expected, we found NoGo trials to be associated with greater negativity as compared to Go trials from approximately 230 ms onwards. We further investigated this N200 effect by computing NoGo–Go difference waves in congruent and incongruent trials separately. Crucially, we found delayed negativity in incongruent

¹ It should be kept in mind that the present sample of participants comprised mostly women.

as compared to congruent trials. In fact, the N200 onset latency was approximately 60 ms later in the incongruent trials relative to the congruent trials. These electrophysiological data show that the implicit associations must have been activated much earlier, i.e. at the point of divergence between the N200 effects in congruent and incongruent trials. Note that this value, in the present study about 230 ms, can be taken as the upper limit of the time at which this automatic attitude information becomes available (see Rodriguez-Fornells et al., 2002, 2005; Schmitt et al., 2000, 2001, for a similar logic in tacit picture naming experiments). The scalp topography of the N200 in the present experiment (Fig. 3) is consistent with previous experiments and shows a frontal distribution.

We also calculated difference waves for trials in incongruent blocks minus trials in congruent blocks for both Go and NoGo conditions (see Fig. 4). This further investigation of the congruency effect revealed a biphasic nature; there was an early negativity on Go trials and an early positivity followed by a larger negativity on NoGo trials. This is consistent with the notion that the N200 reflects the amount of information in support of suppressing (NoGo) rather than initiating the response (Go). For NoGo trials, it is likely that the automatic associations already in place interfered with the task instructions to withhold a response, resulting in a smaller and later N200. For example, when instructed ‘press if a young face or a bad word’, an elderly face activates negative associations that suggest that the button needs to be pressed. Similarly, the early negativity found for Go trials suggests an early partial inhibition of the response. For example, when instructed ‘press if a young face or a bad word’, a young face activates positive associations that suggest that a response needs to be withheld. These results are important as they further elucidate the time course of this type of information processing and show how attitudes, as measured by implicit associations, can affect early stages of processing. Please note that we have observed a similar biphasic incongruency effect in an earlier ERP study on the GNAT investigating implicit associations towards fruit and bug words (see Fig. 2 in Banfield et al., 2006). Also, in a Go/NoGo task investigating implicit activation of phonological information of the non-target language in German–Spanish bilinguals, we also observed a similar biphasic nature of incongruency effects (Rodriguez-Fornells et al., 2005).

As these effects occur so early, they lend further support to the idea that attitude information can be automatically activated and can occur out of awareness (e.g., Fazio, 2001; Greenwald and Banaji, 1995; Greenwald and Farnham, 2000; Greenwald et al., 1998; Nosek and Banaji, 2001).

Importantly, both congruency effects on the N200 were confined to the processing of faces and did not occur for the ERPs of the good and bad words. This suggests that it is not the incongruency per se that drives the N200 effect (if this was the case, we should have observed N200 latency effects for the good/bad words as well, which we have not), but rather the activation of positive or negative prior associations that occurs as a consequence of viewing the young and old faces (see Hebb, 1949). The good and bad words are not likely to be associated with young and old faces, respectively, and are therefore unlikely to produce early conflicting information in the same way that faces do with the evaluations good and

bad. Of course, bad (good) words will activate negative / positive associations but this will not extend to pictures of old and new faces (at least not to in the same way as these faces activate their evaluative associations “bad” and “good”). Why then, did we observe RT incongruency effects for the evaluative words? As RT effects occur considerably later than the ERP components, they will also reflect later, more strategy-based processing. Following Brendl et al. (2001), who have convincingly shown that subjects can shift their response criterion when completing the IAT, we argue that the RT effects for the words may reflect a strategy on the subjects’ part to delay the response in the face of incongruent instructions. Although it is possible that a similar mechanism could account for the early N200 onset effect, the absence of a congruency effect for the word trials together with the specific biphasic nature of the congruency effect for faces, makes it unlikely that the delay in N200 onset simply reflects a strategic slowing in incongruent blocks. This is in line with an earlier EEG study using the GNAT where we only found N200 effects for the taxonomic categories fruits and bugs but an RT effects for both, fruit and bug words and evaluative good and bad words (Banfield et al., 2006).

Finally, it might well be that the GNAT or the IAT are influenced by associations that are not necessarily in line with the subject’s personal evaluation of the category in question, but rather reflect knowledge of societal norms or stereotypes, for example (Karpinski and Hilton, 2001). Is it possible then to regulate how such automatic associations affect our subsequent cognition and behaviour? Behavioural studies have shed some light on this issue (Payne, 2001), but neurophysiological measures may also be ideally suited to this investigation, e.g. by looking at brain potential components known to indicate response conflict (Amodio et al., 2004). It may be the case that while automatic associations are reflected in the time-window 170–230 ms, later ERP components reflect more controlled, processes associated with the regulation of behaviour. Future work should address these issues.

In conclusion, we find evidence of automatic attitude activation as early as 230 ms post stimulus onset. In a Go/NoGo association task, we found a delayed N200 for trials in incongruent as compared to congruent blocks, reflecting suppression of associative information held between the target category and either pole of an evaluative dimension.

3. Experimental procedures

All procedures had been cleared by the local ethical review board.

3.1. Participants

Sixteen students at the University of Magdeburg (13 women, mean age 22) participated. All were right-handed, healthy, native speakers of German.

3.2. Materials and paradigm

Positive and negative words (40 in each category) were matched for length and word frequency (Baayen et al., 1993) and had been piloted for valence in an independent subject sample on a 5 point Likert scale (ranging from 1, very good, to 5, very bad).

For good words a mean of 1.68 (range 1–2.6) and for the bad words a mean of 4.30 (range 3.2–5) was obtained. These stimuli had also been used in Banfield et al. (2006). Word stimuli were presented in black (Arial, 16 pt) against a white background. Black and white photographs of 40 elderly and 40 young faces (20 women in each category) showing a neutral facial expression were used. All photographs were cropped to the same specification (75×105 pixels), had a similar background colour and subtended approximately 4° of visual angle in height and approximately 7° in width at a viewing distance of 80 cm.

Eight experimental blocks (two blocks per condition) each contained 176 trials, comprising 160 experimental stimuli preceded by an additional 16 practice trials. Each block lasted approximately 9 min. The same word and face stimuli were arranged in random order within each block. At the start of each trial, a fixation cross was centrally presented for a random duration between 500 and 1500 ms immediately followed by either a word or a face which remained on the screen for 2000 ms, followed again by a fixation cross for 500 ms until the end of the trial. Participants were required to make a Go/NoGo decision on the presentation of each stimulus, depending on the instructions given at the start of the block, and again as a reminder at the end of the practice trials. There were four experimental conditions which determined the decision: two congruent (press if *elderly* [face] or *negative* [word]; press if *young* or *positive*), and two incongruent (press if *elderly* or *positive*; press if *young* or *negative*). The order of blocks was rotated and counter-balanced across participants. While there are some indications that attitudes towards elderly women are more negative than towards elderly men, we did not include gender as a variable because of signal-to-noise considerations.

The EEG was recorded from 29 scalp electrodes against a reference at the right mastoid process using standard procedures (Rodríguez-Fornells et al., 2005; Schmitt et al., 2000, 2001). The electrophysiological signals were filtered with a bandpass of 0.01–70 Hz (half-amplitude cutoffs) and digitized at a rate of 250 Hz. Trials on which base-to-peak electro-oculogram (EOG) amplitude exceeded 75 µV, amplifier saturation occurred, or the baseline shift exceeded 200 µV/s were automatically rejected off-line (27%). Trials with correct responses were averaged separately for congruent and incongruent conditions, and for face and word stimuli, for epochs of 1024 ms including a 100 ms pre-stimulus baseline. All ERP waveforms were digitally filtered using a low-pass filter of 7 Hz for display. However, mean amplitudes for statistical analyses were computed with unfiltered waveforms.

Acknowledgments

This work was supported by grants from the Deutsche Forschungsgemeinschaft and the BMBF.

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