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Implicit and explicit emotional processing in Parkinson’s disease

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Introduction: Our study investigated the ability of non-demented Parkinson’s disease (PD) patients to explicitly identify emotional words and to show implicit sensitivity to these emotions in a task that did not require emotional processing.

Methods: Twelve PD patients and 12 healthy controls, matched for age and education, performed lexical decision (LD) and emotional categorisation tasks (fear, disgust, and happiness) on the same words.

Results: PD patients were specifically impaired in the explicit identification of disgust with a decreased accuracy in LD. However, a slowdown in LD latency in both PD patients and the control group suggested the persistence of emotional sensitivity to disgust.

Conclusion: Despite the persistence of an automatic capture by the emotional content of disgust, PD patients may suffer from emotional deficits in recognising both the emotional and semantic components of words, resulting in blunted emotional responses.

Keywords: Parkinson’s disease; Emotion; Disgust; Implicit processing; Explicit processing.

Psychobehavioural disorders, especially communication disorders observed in Parkinson’s disease (PD), may be associated with dopaminergic depletion in basal ganglia and limbic brain regions. In fact, impaired emotional control (Dujardin et al., 2004), apathy (Pluck & Brown, 2002), depression (Oguru, Tachibana, Toda, Okuda, & Oka, 2010), and anxious disturbances (Marsh, 2000; Richard, Schiffer, & Kurlan, 1996) may occur successively or simultaneously during the progression of the disease. PD patients show less expressive spontaneous facial expressions in response to emotional video clips (M. C. Smith, Smith, & Ellgring, 1996) and reduced abilities to express emotional prosody (Heilman, Blonder, Bowers, & Crucian, 2000). In addition to reduced emotional behavioural outputs, PD patients present emotional processing deficits as they fail to recognise and rate various social messages conveyed through prosody and facial expressions (e.g., Dujardin et al., 2004; Jacobs, Shuren, Bowers, & Heilman, 1995; Lachenal-Chevallet et al., 2006; Sprengelmeyer et al., 2003; Suzuki, Hoshini, Shigemasu, & Kawamura, 2006; Yip, Lee, Ho, Tsang, & Li, 2003).

In the assessment of PD patients, judgments of emotional words have received little attention with seemingly divergent results. Kan, Kawamura, Hasegawa, Mochizuku, and Nakamura (2002) investigated the ability of PD patients to process emotions from both written sentences and facial expressions. They reported diminished abilities in recognising facial expressions of disgust and fear, but failed to show any impairment of emotional judgement in the written stimuli. In contrast, Hillier, Beversdorf, Raymer, Williamson, and Heilman (2007) asked PD patients to rate the emotional connotations of written words representing a variety of emotion intensities. The pattern of results showed that the valence (positive–negative) and arousal (excited–calm) ratings were impaired in patients, while the ratings of the control expense words (expensive–cheap) were not. The discrepancy between the two groups suggests that the clinical manifestations of PD may not only be due to motor impairments, but also to emotional processing deficits.
between these two studies is most probably due to the different stimuli used, being sentences in the case of Kan et al. (2002) and words in that of Hillier et al. (2007). Moreover, emotions were not examined in the same way. Kan et al. manipulated sentences depicting six basic emotions, including happiness, sadness, anger, fear, and disgust, whereas Hillier et al. did not consider basic emotions but selected instead negative and positive stimuli and classified them according to arousal and cost range, from inexpensive (i.e., crayon) to expensive (i.e., pearl). In addition, the mode of response was different in the two studies. In the study of Kan et al., participants were asked to select a card expressing the basic emotion that best described the emotional state represented in the sentence. In the study of Hillier et al., participants rated the emotional valence, arousal, and expense of certain words according to a visual Likert scale. By consequence, the emotional impairment of PD patients during the processing of words still needs to be confirmed.

Emotional functioning encompasses both explicit and implicit processes, which are impaired to a different extent in PD patients. Emotional judgement concerns knowledge of an emotion and its intensity while being experienced. This process involves an explicit response during late postperceptual stages and requires sophisticated mechanisms that involve executive functioning. Emotional judgement results from the interpretation of somatic states or early affective reactions. In contrast, other tasks involve the implicit and automatic effects of emotion, which appear when participants ignore the emotional content and direct their attention explicitly to other features of the stimulus. Event-related brain potential (ERP) studies have identified the implicit effect of emotion-inducing stimuli in nonemotional detection tasks under free-viewing conditions (Schupp, Junghöfer, Weike, & Hamm, 2003; Wieser et al., 2006). Similarly, behavioural studies in which participants were required to focus their attention on the non-emotional features of stimuli (e.g., Algom, Chajut, & Ley, 2004; Estes & Verges, 2008) confirmed the modulation of performance by emotional content. However, to our knowledge, few studies have compared explicit and implicit emotional processing in PD patients in order to identify the stage at which impairment occurs. Recently, Wieser et al. (2006) confirmed that PD patients explicitly rated pictures of highly arousing content as less exciting than did healthy controls. However, ERPs showed an automatic reactivity to the emotional content of the pictures. Emotional deficits in PD patients were therefore interpreted to reflect blunted emotional responses, which may be partly due to a disturbance in executive functioning, whereas the automatic emotional sensitivity of patients was spared.

As aforementioned, emotion processing appears to take place in two modes, which are represented differently in conscious awareness. In our study, we investigated the implicit and explicit processes of emotional responses. We compared three categories of emotions (fear, disgust, and happiness), as previous studies reported more severe impairments in emotional recognition of facial expressions of disgust in PD (Suzuki et al., 2006), as well as in Huntington’s disease (Hennenlotter et al., 2004; Sprengelmeyer, Young, Sprengelmeyer, et al., 1997), whereas other studies revealed decreased performance for both disgust and fear (Kan et al., 2002; Lachenal-Chevallet et al., 2006). We chose to use words as the basis of assessment since, to the best of our knowledge, no study to date has demonstrated impairments for the emotions of disgust or fear using verbal materials.

In the implicit mode, we used the lexical decision (LD) task on written words, as it did not emphasize emotional features, thus allowing us to evaluate implicit emotional processing. As compared to neutral words, the rapid processing of aversive content of relating to negatively connoted words was shown to result in interference and increased response latency in healthy participants (Algom et al., 2004; Estes & Adelman, 2008). In PD patients, this effect would indicate the persistence of automatic emotional sensitivity to words. Wieser et al. (2006) reported that the automatic emotional processes were unaffected in PD patients. Thus, we predicted delayed reaction times especially for words expressing disgust in both the PD and control groups. In addition, the emotional connotation of words was shown to improve response accuracy in healthy participants, as it enhanced the associated recognition potential by increasing semantic analysis (Kissler, Assadollahi, & Herbert, 2006). Therefore, we also expected correct response rates to provide insights about the persistence of efficient relations between the emotional and semantic components of words. As emotional evaluation deficits of lexical and semantic features were linked to Parsinson’s disease (Castner et al., 2007), we predicted fewer correct responses in PD patients compared to controls, when participants had to classify stimuli as words or pseudo-words.

Based on the results of Wieser et al. (2006), PD patients were assumed to be significantly less accurate than control participants in the explicit mode of emotional processing. In order to address
this issue, we conducted a second experiment, in which participants categorised words as emotional or nonemotional. In this categorisation task, PD patients were assumed to have fewer correct responses compared with controls.

**METHODS**

**Participants**

In total, 12 nondemented PD patients and 12 healthy controls participated in the study. The PD patients (10 men and 2 women; mean age: 66 ± 7; mean education: 9 ± 0.9) were recruited from the neurological department of Bellevue (Saint-Etienne Hospital, France). All patients were diagnosed with idiopathic PD by a neurologist according to the criteria of the United Kingdom Parkinson’s Disease Brain Bank (Gibb & Lees, 1988). Motor symptom severity was assessed according to the Unified Parkinson’s Disease Rating Scale (UPDRS) (Fahn & Members of the UPDRS Development Committee, 1987) part III in the On-drug condition. Their mean UPDRS III score was 20.08 (± 6.25; range: 10–27). The mean duration of the disease was 6.58 (± 4.14) years (range: 2–15). All patients were treated with L-dopa, and some patients were simultaneously under dopamine agonist medication (pramipexole, ropinirole, piribedil). The mean total L-dopa equivalent daily dosage was 583.33 mg (±241.52). Patients exhibited no cognitive impairment that interfered with their autonomy. They underwent the Mattis Dementia Rating Scale (Mattis, 1976), including executive functions and anterograde memory assessment (Table 1), and obtained a higher score than the lowest quintile of the reference population (Schmidt et al., 1994).

The healthy participants were recruited among the parents of departmental staff members or outside the neurology service. Twelve healthy controls (4 women and 8 men, mean age: 66 ± 6 year; mean education: 9 years ± 0.85) were matched to the patients for age and education level. Exclusion criteria for healthy participants included any current psychiatric or neurological disorder. Dementia was an exclusion criterion for all participants, as indicated by a score >27 on the French version of the Mini Mental State Examination (MMSE, Folstein, Folstein, & McHugh, 1975).

In addition, the mood of PD patients and control participants was assessed in order to minimise the influence of variables, such as depression or anxiety. Depressive mood was evaluated using the depression questionnaire QD2A (Pichot et al., 1984) and anxiety by the Questionnaire Anxiety Scale (Goldberg, Bridges, Duncan-Jones, & Grayson, 1988). Participants with scores exceeding the cut-off thresholds (≥7 for the QD2A and ≥5 for the Questionnaire Anxiety Scale) were excluded from participating in the study. Therefore, none of the PD patients met the criteria for anxiety or depression.

**Materials**

A set of 128 written stimuli (64 words and 64 pseudo-words) in French was used. Words were divided into four emotional categories: 16 were pleasant (e.g., “amitié”, friendship), 16 fear-related (e.g., “horreur”, horror), 16 disgust-related (e.g., “vomi”, vomit) and 16 neutral (e.g., “table”, table). The four word categories were matched for written lexical frequency, number of letters, phonemes, and syllables (Content, Radeau, & Mousty, 1990). The number of letters, phonemes, and syllables was also checked for the pseudo-words to discourage any strategy. The list of stimuli was divided into four blocks, with their order of presentation counterbalanced across subjects.

**Procedure**

**Lexical decision task (implicit emotional processing)**

Each participant first performed LD task on the 128 words and pseudo-words. Each trial began with a fixation cross displayed at the centre of the screen for 500 ms. It was immediately replaced by the written target, which remained on the screen until the participant decided whether it was a word or not, by pressing the right or left corresponding button as quickly and accurately as possible. For half of
the participants, the response keys were reversed. In each block session, the stimuli were presented in a random order. The inter-stimulus interval (ISI) lasted 1500 ms.

**Categorisation of emotions (explicit emotional processing)**

The participants were presented with the same words used in the previous experiment, and had to explicitly identify the category of the emotion induced by the word. During the first 500 ms of the trial, a fixation point was displayed at the centre of the screen and, then replaced by a word. The participants were invited to decide whether the semantic representation of the word was related to one of the three emotional categories “fear”, “disgust”, or “happiness”. The word could also be categorised as “neutral”, if unrelated to any emotion, or “other” if judged by the participant to be related to another emotion such as “anger” or “surprise”. The target remained on the screen until the participant responded by pressing the button corresponding to his chosen response. The stimuli were presented in a random order.

**Data analysis**

Results are expressed as mean ± standard error. All statistical comparisons between patients and controls were performed using a parametric test (analysis of variance, ANOVA) for the LD task. A two-way ANOVA—2 (group: Parkinson’s disease, controls) × 4 (emotional content: neutral, disgust, fear, happiness, repeated measures)—was carried out on mean response times and percentage of correct responses. Response times, greater than two standard deviations above or below the mean were removed (less than 5% of data), which eliminated outliers and inconsistent data. In addition, as we considered the percentage of correct responses when participants had to classify words or pseudo-words, the arcsine transformation was used, in order to ensure that the data-set was normally distributed.

In the categorisation task, we considered only the percentage of correct responses. Due to the non-normal distribution and great variability of the data in this second experiment, the $Q'$ factorial test (Michael, 2007) was carried out. The procedure consisted of eliminating group variance by pooling the data across subjects. The pooled proportion of correct responses was subsequently submitted to factorial analysis according to group (PD and control) and emotional content (disgust, fear, happiness and neutral).

**RESULTS**

**Lexical decision**

There were no main effect for the group nor were there any significant interactions between group and emotional content. However, there was a main effect for emotional content $F(3,66) = 11.66$, $p < .0001$. Planned comparisons indicated longer latencies for disgust-connoted words than for neutral, fear-related and happiness words ($p < .01$). Thus, the pattern of results was similar in the two groups, being especially characterised by the LD lengthening on disgust-connoted words.

Similar analyses were conducted on the percentages of correct answers. There were significant effects for group $F(1,22) = 5.13$, $p < 0.03$, and for emotional content $F(3,66) = 5.37$, $p < .002$, along with an interaction between group and emotional content $F(3,66) = 3.44$, $p < .05$. The Student’s test indicated lower performance in PD patients than in controls ($p < .01$) when they classified disgust-connoted stimuli as words or pseudo-words. As shown in the planned comparisons, PD patients performed LD less accurately on disgust-connoted words than on neutral ($p < .006$), fear-connoted ($p < .0002$), and pleasant ($p < .03$) words, while differences between emotional categories did not reach significance in the control group. This interaction is represented in Figure 1.

**Categorisation of emotions**

The main effect of group proved significant $Q'(1) = 11.3$, $p < .0008$ with PD patients having fewer correct responses than controls (.76 vs. .84, respectively). The main effect of emotion also proved significant $Q'(3) = 9.4$, $p < .025$. Multiple corrected comparisons revealed that this effect originated in the difference between neutral and fear (.74 vs. .83, respectively; $p < .03$) and between neutral and happiness (.74 vs. .83, respectively; $p < .03$; see Figure 2). Although the analysis of group by emotional content interaction failed to reach significance $Q'(5.6) = 3$; $p > .13$, multiple comparisons were conducted on account of our a priori hypotheses (Howell, 2007), notably that the two groups would mainly differ in relation to disgust. This was indeed the case with .83 in PD
patients vs. .88 in controls (p < .002). No other differences were found.

**DISCUSSION**

The present study investigated selective impairment of specific emotions in PD. The latencies in the LD task, measuring implicit emotional processing of words, were longer for disgust-connoted words in both PD patients and healthy controls. A number of studies showed such a negative emotional bias through event-related potentials in healthy participants (Carretié, Martín-Loeches, Hinojosa, & Mercado, 2001; Huang & Luo, 2006; N. K. Smith, Cacioppo, Larsen, & Chartrand, 2003). Slower LDs for negative words were also reported in the case of healthy participants, which were interpreted as reflecting the prolonged attentional monitoring of negative stimuli, termed *automatic vigilance* (Algom et al., 2004; Estes & Adelman, 2008). Once detected, negative stimuli are more elaborately processed than positive stimuli, and require greater information processing, which temporarily disrupts all ongoing activity, such as in the case of LD (Dijksterhuis & Aarts, 2003). This defence mechanism is assumed to increase attention allocation by processing stimuli of paramount urgency. The major increase in LD latencies in healthy participants is not surprising, given the evolutionary importance of disgust, as it is associated with the necessity of avoiding any contaminated object from entering the body. In PD patients, it is assumed that the automatic emotional process is relatively preserved, in line with the study of Wieser et al. (2006)

The persistent emotional sensitivity to disgust, as shown by the slowdown by the LD slowdown, is associated with PD patients being less able in the explicit identification disgust. As predicted, and in accordance with the study of Wieser et al. (2006), PD patients showed reduced correct responses for disgusted-connoted words when they categorised stimuli as emotional or not, suggesting the elementary reaction to disgust to be
in PD patients for disgust, but not for fear. Some studies based on the recognition of facial expressions emphasised the specific involvement of the amygdala in fear processing and the striatum and insula in disgust processing (Calder, Keane, Manes, Antoun, & Young, 2000; Krolak-Salmon, Henaff, Bertrand, Vighetto, & Mauguiere, 2003; Phillips et al., 1997; Schienle, Schäfer, Walter, Stark, & Vaitl, 2005; Sprengelmeier, Rausch, Eysel, & Przuntek, 1998; Stark et al., 2007; Wicker et al., 2003), although this distinction is not so clear-cut. L-dopa-therapy along with its specific action on amygdala (Tessitore et al., 2002) may partly explain the spared ability to recognise fear in our PD patients.

As reported in our study, the disproportionate impairment in disgust, categorisation using verbal tasks, reflects the same impairment of disgust found in facial expressions (Suzuki et al., 2006; who attributed their results to the highly controlled nature of their experiment). Nevertheless, other observations of PD patients showed an impairment in both disgust and fear processing (Sprengelmeier, et al., 2003; but see Kan et al., 2002, for a slightly greater impairment of disgust than fear). A disproportionate impairment in recognising disgust was also reported in other neuropsychiatric diseases associated with the dysfunction of the insula (Calder et al., 2000), or the basal ganglia, such as Huntington’s disease (Sprengelmeier, Young, Sprengelmeier, et al., 1997), obsessive-compulsive disorder (Sprengelmeier, Young, Pundt, et al., 1997), and Wilson’s disease (Wang, Hoosain, Yang, Meng, & Wang, 2003). In addition, the deterioration of neural networks including the basal ganglia, insula, and orbito-frontal cortex, was probably responsible for impaired disgust processing in PD patients (Krolak-Salmon et al., 2003).

Overall, our study provided evidence for two important findings concerning the emotional deficits encountered in PD patients. Firstly, the automatic sensitivity of PD patients to the emotional content of written words was spared, despite their poor identification of emotions from connoted words. Secondly, the identification of disgust was disproportionately impaired in our non-demented PD patients. This specific deficit may be associated with abnormal olfactory and gustatory functions (Forsleff, Schauss, Bier, & Stuart, 1999; Mesholam, Moberg, Mahr, & Doty, 1998), which would be interesting to explore in future research. The small sample size of our study population calls for cautious interpretation of the results. Further experiments conducted with words connoting emotions would certainly improve our
understanding of the emotional disorders observed in the early stages of this pathology.

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