# Static versus Dynamic Measures of Facial Expression in Parkinson's Disease

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## ABSTRACT

Investigations of voluntary facial emotions in Parkinson's disease (PD) have primarily employed subjective ratings of "static" images. We have recently suggested that the use of objective computerized imaging techniques for quantifying "dynamic" facial expressions may provide a highly sensitive method to detect differences in emotional expressivity between PD patients and normal controls (NC). The present study complements and expands concurrent investigations by comparing the static-subjective and the dynamic-objective methodologies for studying facial expressions. **Methods:** Parkinson patients (Hoehn-Yahr < 3) and age- and educated-matched Controls were videotaped while producing six voluntary facial emotions. Computerized imaging techniques were used to quantify dynamic facial expressions. An overall movement change value ("entropy") was obtained for each expression. Pictures of the peak facial expression for each emotion were shown to 25 raters who rated each static expression for intensity and valence. Thus, both objective movement values and subjective ratings were available. **Results:** As expected, PD patients were not rated as significantly worse than normal controls in terms of intensity or valence of the static facial expressions. Overall, the majority of subjective ratings of static images were not significantly correlated with the entropy or movement changes. **Conclusions:** The present study suggests that subjective ratings of static images may not be a highly sensitive method for detecting reduced facial expressivity in PD. Further, ratings of static facial expressions are not reliably associated with dynamic entropy values. These findings support the uniqueness of the dynamic-objective method as a sensitive indicator of reduced expressivity.

## INTRODUCTION

"Masked facies" or flattened facial affect is one of the cardinal symptoms of Parkinson's disease (PD). Neuroanatomically, voluntary facial expressions are mediated by fronto-cortical systems, whereas spontaneous or automatic facial expressions are mediated by subcortical systems (e.., basal ganglia, limbic). Based on this distinction, PD patients should have difficulty with spontaneous facial expressions, whilst maintaining relatively intact ability to pose facial expressions on command. Several recent studies have challenged this traditional conceptualization, reporting diminished emotional expressivity in PD during posed conditions (Heilman et al., 2000; Bowers et al., 2003). Thus, both neuroanatomical systems of facial expressivity (e.g., voluntary and spontaneous) may be compromised in at least a subset of the PD population.

Historically, most studies of voluntary facial emotions in PD have primarily used subjective ratings of "static" images. Recently, we have developed a computerized imaging technique that enables us to quantify "dynamic" movements and changes in facial expressions over time. This methodology enables one to explore the entire range of facial movement, as an expression evolves across a time lapse, as opposed to a static, snapshot evaluation of the intended facial expression. Furthermore, it is then possible to design specific algorithms to quantify facial expressions in an objective manner independent of any raters. One such algorithm, an "entropy" value, reflects the overall change in movement for each expression.

**Purpose/Hypotheses:** We recently suggested that the dynamic imaging technique may provide a highly sensitive method to detect differences in emotional expressivity between PD patients and normal controls. The purpose of the present study was to compare static-subjective ratings with the dynamic-objective methodology for quantifying facial expressions in PD patients and normal controls. We hypothesized that raters would subjectively judge the intensity and valence of the expressions of PD faces lower than NC faces. Further, entropy values derived from computer imaging would correlate strongly with subjective ratings.

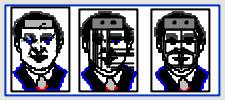
## METHOD

**PARTICIPANTS:**
- 25 Raters, University of Florida undergraduate and graduate students (10 male and 15 female)
  - Mean age = 25.2

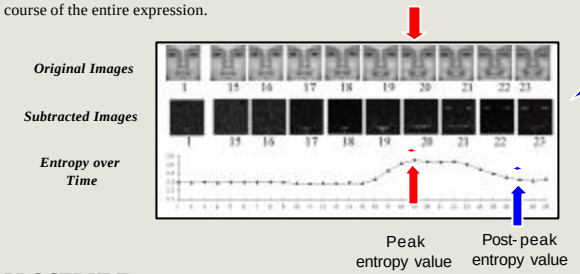
**FACIAL STIMULI:**
- 4 male PD patients (Hoehn-Yahr < 3)
- 4 male Normal Controls, matched on age and education
- PD patients and NC participants were asked to pose one of 6 facial expressions (se below): Happiness, Sadness, Fear, Anger, Disgust, and Surprise

**VIDEOTAPING & DIGITIZING FRAMES:**
The 4 PD and 4 controls were videotaped while making voluntary emotional expressions (sadness, anger, fear, disgust, surprise, happiness). Each trial began with the presentation of a card denoting the target emotion. For each expression the initial 30 videoframes were captured, digitized, and saved on the hard drive of a computer. Each digitized frame was 30 ms in duration and represented a 640 X 480 pixel array at 256 levels of gray scale.

**LANDMARKING THE FACE:**
Sixteen anatomic landmarks were placed on the face using a mouse. This was done on the 1st frame of an expression sequence. Custom soft-ware in PV Wave (CHEES) used these landmarks to automatically compute geographic boundaries or regions of interest (ROI) that were applied to all images of a particular expression.



**COMPUTING MOVEMENT CHANGE (ENTROPY):**
For each expression, pixel intensities of adjacent frames were subtracted to obtain difference images over time (see below). On these difference images, we plotted histograms of the region of interest (see below). Custom software, developed by Gokcay, was then used to compute total Entropy, a quantitative index of movement change over the face during the course of the entire expression.




**PROCEDURE:**
- Entropy values were computed during the entire length of each emotional expression
- Face images corresponding to the PEAK entropy values were used for subjective ratings, i.e., those values representing the greatest change in facial movement during an expression
- Static-subjective ratings were obtained by asking Raters to judge the peak entropy static images of each expression on the dimensions of valence and intensity
- Raters were blind as to which faces belonged to a PD versus a Normal Control face
- Ratings for each expression were obtained on a 9-point Likert scale
- Dynamic-objective ratings were the peak entropy values for each expression

## RESULTS

***Demographic Info for Stimuli Faces*** (SDs in parentheses)

| | Age | Education | BDI score | Years w/ PD |
|---|---|---|---|---|
| Controls | 72.7 (9.91) | 15.75 (2.06) | 4.25 (1.5) | N/A |
| PD patients | 73.5 (9.81) | 15.75 (5.32) | 8.5 (2.65) | 3.6 (1.70) |

- As shown in table 1, there were no significant differences between PD and Normal Controls (NC) on most ratings of intensity and valence across the 6 static facial expressions
- However, the expression of Anger was rated more intense for PD than NC participants.

**Table 1. Mean Static-Subjective Ratings of Facial Expressions**

| | | NC Mean Rating | PD Mean Rating | t-value | p-value |
|---|---|---|---|---|---|
| Valence | Anger | 3.92 | 4.41 | -.50 | .65 |
| | Disgust | 3.93 | 3.60 | .07 | .95 |
| | Fear | 4.59 | 3.73 | 2.29 | .08 |
| | Happiness | 6.35 | 5.81 | .57 | .60 |
| | Sadness | 3.84 | 4.13 | -1.42 | .25 |
| | Surprise | 4.96 | 3.95 | 2.03 | .13 |
| Intensity | Anger | 5.71 | 5.20 | .48 | .67 |
| | Disgust | 4.09 | 4.71 | -1.35 | .27 |
| | Fear | 3.49 | 4.98 | -4.46 | .02 |
| | Happiness | 3.80 | 4.89 | -1.46 | .23 |
| | Sadness | 3.71 | 3.64 | .16 | .88 |
| | Surprise | 3.52 | 4.25 | -1.44 | .25 |

**Subjective Ratings**
No significant differences between PD and NC for most ratings

**Dynamic-Entropy Scores**
PD patients had significantly less movement and were significantly slower to reach a peak expression than NC

**Relationship between Static-Subjective and Dynamic-Objective**
Overall, the majority of subjective ratings of static images were not significantly correlated with the entropy or movement changes

**STUDY 2: RATINGS OF POST-PEAK EXPRESIONS:**
**In a follow-up study, we compared subjective ratings of face images taken at the post-peak entropy point to the dynamic entropy movement score.**
- 20 additional Raters (9 males, 11 female undergraduate students); intensity and valence ratings of post-peak static images

Results: Similar to those obtained with peak entropy values. No significant difference between PD and NC images on either intensity or valence ratings; no correlation with entropy.

## CONCLUSION

We previously used a computer imaging technique and found that PD patients had reduced facial mobility and were significantly slowed in reaching a peak emotional facial expression. In the present study, we examined subjective ratings of facial emotion and how these subjective ratings corresponded to our dynamic imaging findings (entropy). In contrast to entropy measures, there were no significant differences in subjective ratings of intensity and valence of the static expressions of PD compared to NC faces. Thus, subjective ratings of static images may not be a highly sensitive method for detecting reduced facial expressivity in PD. Further, dynamic entropy values did not correlate strongly with the participants' subjective ratings of static facial expressions (either peak or post-peak).

Taken together, these findings support the unique contribution of the dynamic-objective method as a sensitive indicator of reduced expressivity. Our results highlight the relevance of methodological approaches in future investigation of emotional expressivity in neurological, psychiatric, and normal populations.

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