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Detecting facial characteristics of Parkinson's disease by novel artificial intelligence (AI) softwares

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Abstract

Parkinson's disease (PD) patients usually develop facial abnormalities as a result of both motor and non-motor impairments. In the present study, 96 healthy Japanese control subjects and 97 Japanese PD patients were analyzed for the facial appearance age, emotion and skin condition by novel artificial intelligence (AI) softwares. Because an appearance age of our Asian subjects was younger than their real age, we newly adjusted it for Japanese. The age-adjusted AI software looked age of PD patients as 2.4 years older than healthy control subjects ($*p < 0.05$). The gap between appearance age and real age was larger in male and younger PD patients than in female and older patients, respectively. In the AI facial emotion analysis, expressionless was obviously more frequent and happiness was less frequent in PD than in control ($*p < 0.05$). On the other hand, facial skin condition didn't show any difference between PD and control. The present AI face recognition software thus clearly detected the facial outlook of PD corresponding to clinical expressions.

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Key words: artificial intelligence(AI); emotion; face; Parkinson's disease; skin

Abbreviations: AI, artificial intelligence; PD, Parkinson's disease.

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Introduction

Facial appearance significantly influences our social life (Schmidt and Cohn, 2001). First impression is formed mainly from faces (Zebrowitz and Montepare, 2008), and facial appearance affects social outcomes such as science communication (Gheorghiu et al., 2017) and voting (Franklin and Zebrowitz, 2016). People are even suffered from their own appearance-related distress (Hassan et al., 2009).

Parkinson's disease (PD) is a progressive neurodegenerative disease characterized by motor symptoms such as resting tremor, rigidity, and bradykinesia as well as non-motor symptoms including autonomic dysfunction, neuropsychiatric symptoms and sensory disturbance (DeMaagd and Philip, 2015). PD patients usually develop facial abnormalities as a result of both motor and non-motor impairments (Chaudhuri et al., 2005), which may occasionally disturb their relationship with their care partners (Gunnery et al., 2016).

A recent development of artificial intelligence (AI) technology provides us powerful applications which automatically detects faces and estimates their characteristics such as age, emotion, and skin conditions from digital photographs. Because this AI technology could also be useful for evaluating facial changes in PD patients, we examined the facial changes in PD patients by using novel AI softwares in the present study.

Materials and Methods

Study participants

A total of 193 subjects consisting of 96 healthy control subjects and 97 PD patients were enrolled in the present study from May 2020 to August 2020. The diagnosis of PD was made by neurologists based on the movement disorder society clinical diagnostic criteria for Parkinson's disease (established or probable PD) (Postuma et al., 2015). All of the participants underwent face and facial skin condition analyses in a consulting room of our clinic. All participants gave written informed consent, and the Okayama University Ethical Review Board approved all study procedures (approval #OKU-1819).

Facial analysis

Face of each participant was photographed with a web camera, and analyzed with a commercially available AI software, Microsoft Azure Face (Microsoft Corp., Washington, USA), which detects the face from a photograph and automatically analyzes its attributes such as age, gender and emotion in 1 sec. In the present study, estimated age (appearance age) and emotion (expressionless, happiness, sadness, contempt, surprise, anger, disgust and fear) were evaluated. Age gap was calculated as difference between appearance age and real age (age gap above 0 means that appearance age is older than real age). Participants were not given any instructions about their facial expression when being photographed.

Facial skin condition analysis

Facial skin condition analysis was performed with a smartphone application FACE LOG ver 1.08 (NTT docomo Inc., Tokyo, Japan). Facial skin was photographed with and without flash in succession, and then skin score (range: 0 - 100, the higher the better) and skin items (stain, wrinkle, shadow under eyes and pore) scores (range: 0 - 100, the higher the better) were automatically calculated in 2 sec.

Statistical analysis

Comparisons of age, emotion and skin scores between control and PD were carried out with Student's t-test or Mann-Whitney U test, and comparison of gender was carried out with Pearson's chi-square test. Jonckheere-Terpstra test was performed to analyze the trend. All of the statistical analyses were performed with SPSS 22.0.0.0 (IBM Corp., Armonk, New York, USA). Statistical significance was assumed at $p < 0.05$.

Results

Characteristics of the study participants

Demographic and clinical characteristics of the study participants are shown in Table 1. The real age of control subjects (69.5 ± 10.2, n = 96) and PD patients (69.5 ± 9.5, n = 97) were the same, and female ratio was not significantly different between control (68.8 %) and PD (55.7 %). Out of 97 PD patients, 69 (71.1 %) were

Table 1. Demographic and clinical characteristics of the study participants

		PD					
	Control	**Total**	**Yahr 1**	**Yahr 2**	**Yahr 3**	**Yahr 4**	**Yahr 5**
n	96	97	1	17	69	9	1
Female (%)	68.8	55.7	100	58.8	55.1	55.6	0
Mean age (y)	69.5 ± 10.2	69.5 ± 9.5	58	68.9 ± 13.1	69.8 ± 8.8	75.6 ± 4.6	73

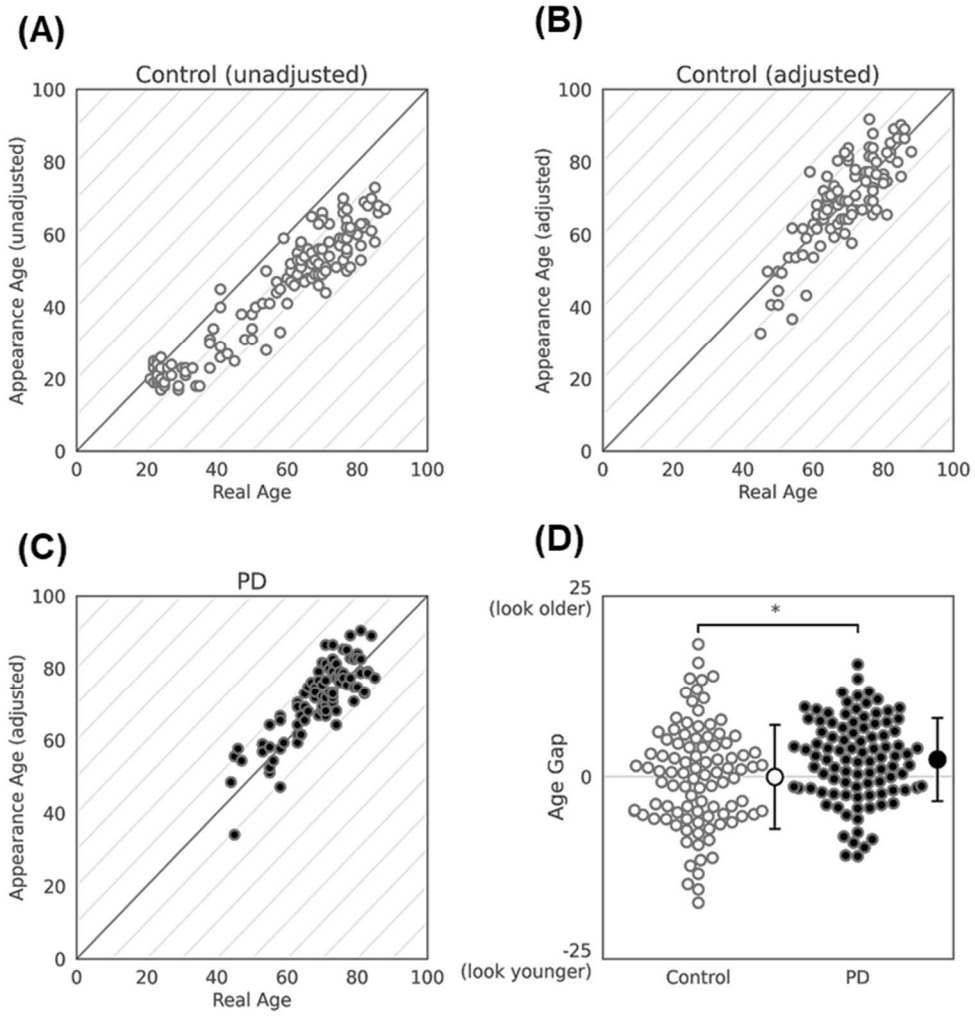

Fig. 1 (A) Unadjusted original version of appearance age for Japanese control subjects (n = 143), showing younger deviation than their real age. (B) After adjusting of appearance age of control subjects (n = 96) to set the gradient as 1.00. (C) Appearance age of PD patients (n = 97) with the above age-adjusted program. (D) Comparison of age gap (appearance age - real age), showing a significantly older appearance in PD than control (*$p < 0.05$).

at Hoehn and Yahr stage 3 (Table 1).

Appearance age analysis

First we collected the appearance age data from the healthy Japanese subjects (n = 143, age 21 - 88 years old), which turned out to be younger than their real age in the original setting obtained mainly from white race (Fig. 1A; gradient of regression line was 0.81 for male and 0.76 for female). Thus, we adjusted their original appearance age to be closer to their real age (Fig. 1B; gradient was set to 1.00 for each gender). With the above age-adjusted program for Japanese, the appearance age of Japanese PD patients was measured (Fig. 1C).

Age gap (appearance age - real age) of control subjects was very small (0.0 ± 7.1 years) after

adjustment (Fig. 1A, 1B). On the other hand, the age gap of PD patients (2.4 ± 5.7 years) was significantly larger (*$p < 0.05$) (Fig. 1C, 1D). Subgroup analyses showed that age gap of PD patients was larger than control subject especially in male (PD, 3.4 ± 5.3 years; control, -0.1 ± 6.7, *$p < 0.05$) compared with female (PD, 1.5 ± 5.9 years; control, -0.0 ± 7.4, $p = 0.21$) (Fig. 2A). There was a significant tendency that elder PD patients had smaller age gap than younger PD patients (age < 60, 2.5 ± 6.9 years; age 60 - 69, 3.8 ± 4.3; age 70 - 79, 2.7 ± 5.5; 80 ≤ age, -1.6 ± 5.7; *$p < 0.05$) (Fig. 2B). Age gap of PD patients was not significantly different among at Hoehn and Yahr stage 1 (0.1 years), stage 2 (0.8 ± 7.5), stage 3 (2.7 ± 5.5), stage 4 (2.2 ± 5.0) and stage 5 (8.6) (Fig. 2C).

Emotion analysis

Emotion of control subjects was most frequently perceived as expressionless (76.6 ± 29.5 %), followed by happiness (18.5 ± 29.5 %) and sadness (4.6 ± 12.3 %). In PD patients, expressionless was significantly more frequent (88.9 ± 16.1 %, *$p < 0.05$) and happiness was less frequent (4.7 ± 12.9 %, *$p < 0.05$)

compared with control. The percentage of contempt, surprise, anger, disgust and fear was not different between control and PD (Fig. 3).

Facial skin analysis

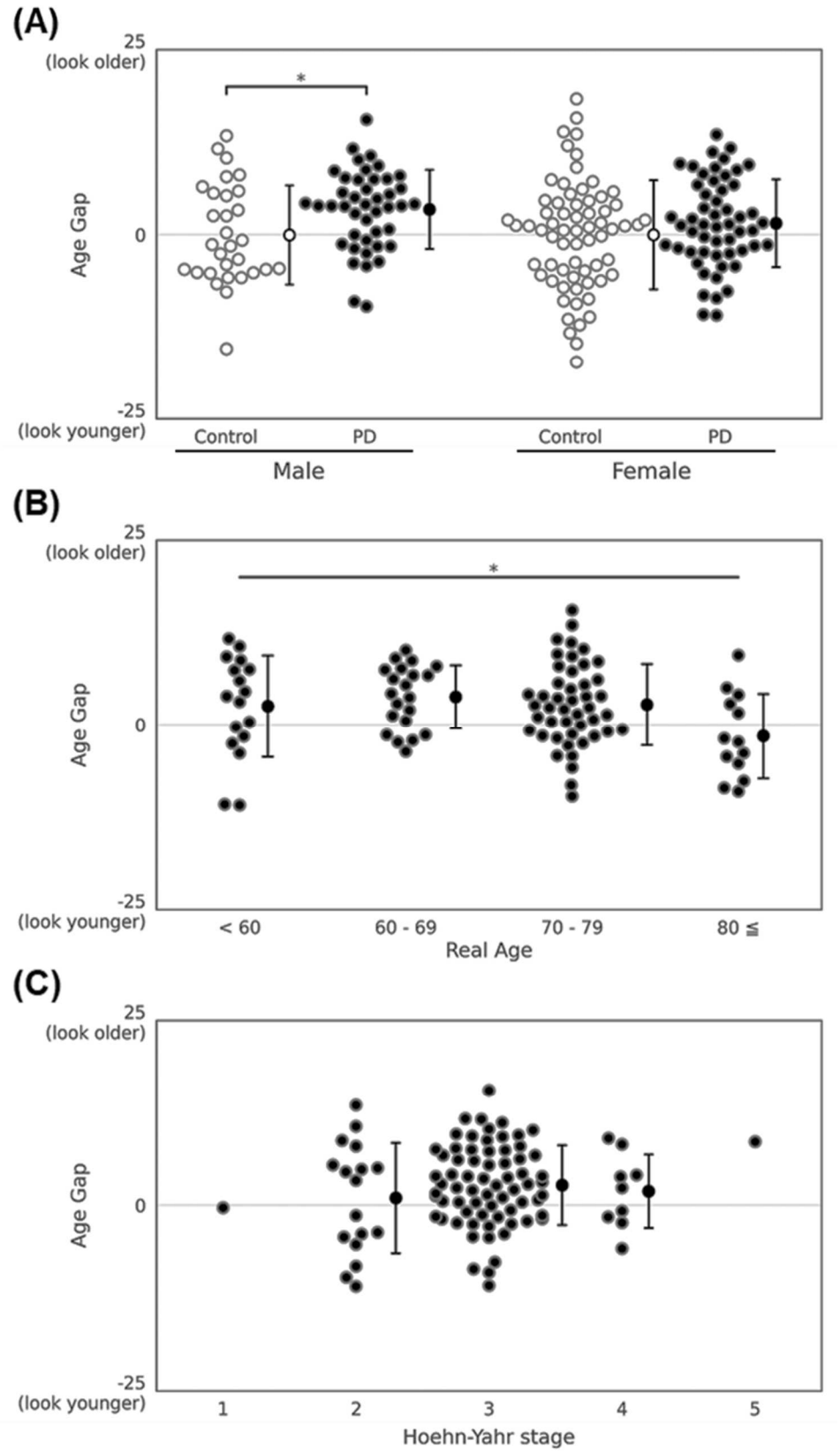

Fig. 2 Subgroup analyses of age gap. (A) Significantly larger age gap of male PD patients than male control (*p < 0.05). (B) A significant tendency of the younger PD the larger age gap (*p < 0.05). (C) No Hoehn and Yahr stage-dependent difference of age gap of PD patients.

(29.7 ± 18.3) and PD (28.5 ± 18.2) (Fig. 4A), and none of the skin items (stain, wrinkle, shadow under eyes, and pore) scores were different between control and PD (Fig. 4B).

Discussion

The present study demonstrated that an AI

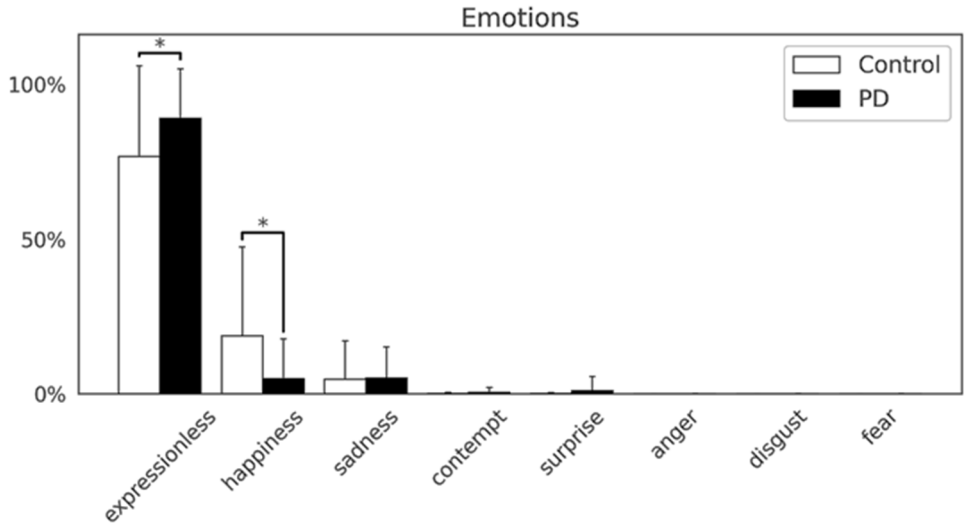

Fig. 3 Emotion analysis, showing a more frequent expressionless and a less frequent happiness in PD patients than control (*$p < 0.05$).

software estimated age of PD patients as 2.4 years older than healthy control subjects (Fig. 1.D). This gap between appearance age and real age (age gap) was larger in male and younger PD patients than in female and older patients, respectively (Fig. 2A, 2.B). In the AI facial emotion analysis, expressionless was obviously more frequent and happiness was less frequent in PD than in control (Fig. 3). On the other hand, facial skin analysis didn't show any difference between PD and control (Fig. 4A, 4B).

Facial movement abnormalities in PD patients is called 'mask like' representing the decreased facial expression (Bologna et al., 2013), which is caused by bradykinesia (Kaneko and Sakamoto, 2001) and rigidity (Hunker et al., 1982) in facial muscles. Although most previous studies evaluated the facial change of PD during movement (Simons et al., 2004; Bowers et al., 2006; Bandini et al., 2017), the present study revealed the facial change of PD based on a single still photograph showing both older appearance age (Fig. 1D) and expressionless face (Fig. 3). Larger age gap in male PD patients than female (Fig. 2A) was possibly because male PD patients presented severer rigidity than female (Baba et al., 2005), or because facial cosmetics masked the facial change predominantly in female. Neuropsychiatric symptoms such as depression, anxiety and apathy may also affect the facial expression (Aarsland et al., 2009). Facial skin of PD patients tends to be oily due to autonomic nervous system dysregulation, and causes seborrheic dermatitis (Ravn et al., 2017). However, the present smartphone application didn't detect any skin change in PD, probably because this application didn't focus on oiliness of the skin (Fig. 4). Another AI software, which is trained with images of seborrheic dermatitis or other skin diseases, might be able to detect the skin change in PD (Han et al., 2020).

Although AI facial recognition is an innovative and powerful technology, several concerns about ethical issues have been raised. One is that classification accuracy of commercial facial recognition software differs depending on gender and skin color, which was

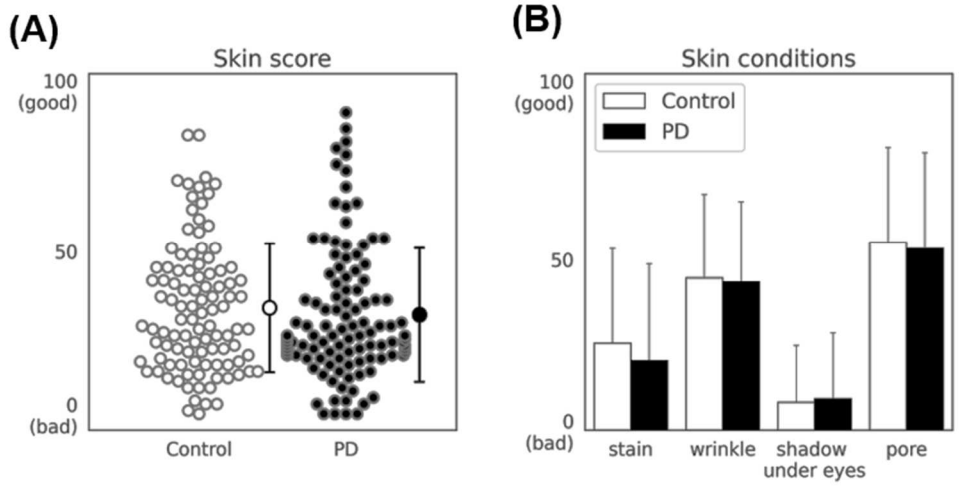

Fig. 4 Facial skin analysis, showing no difference between PD and control in (A) total skin score or (B) any of skin conditions.

seriously lower for darker female people compared with lighter male (Buolamwini J, 2017; Wang and Eng, 2018). In fact, the present study demonstrated that an appearance age of our Asian subjects was younger than their real age (Fig. 1A), and thus we newly adjusted it for Japanese (Fig. 1B, 1C). A potential ethical issue should be carefully discussed and resolved to apply the facial recognition technology to medical situations.

In conclusion, we detected that PD patients looked older and expressionless using publically available AI face recognition software. Although face recognition is a remarkable technology, its ethical risk should also be resolved for clinical application.

Conflicts of interests

None.

Acknowledgements

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