Seeing humanness in older people: the neural connectivity of the ventral and dorsal medial prefrontal cortex modulates perception of the humanness of the elderly

博士論文

Seeing humanness in older people: the neural connectivity of the ventral and dorsal medial prefrontal cortex modulates perception of the humanness of the elderly

（高齢者に対する人間らしさ評価の神経基盤）

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Abstract

Although impacts on the perception of humanness have been examined for a variety of characteristics, studies examining the neural activity of the humanization of specific targets (e.g., older people) are scarce. Therefore, in the present study, I investigated both the effect of target age on perceived humanness and the neural activity in people perceiving the humanness of older and younger targets. Perceived humanness is influenced by two attributes: experience and agency. Thus, participants (n = 35) performed two types of humanness judgments (agency and experience) and judgments of two other characteristics (attractiveness and belonging) regarding older and younger target faces in an MRI scanner. The results indicated that participants rated older targets as having more experience than younger targets. Subsequent functional MRI analyses revealed that no brain regions were parametrically correlated with types of ratings. However, significant functional connectivities between the ventral and dorsal medial prefrontal cortex, as well as the left inferior parietal gyrus and the supramarginal gyrus, were specifically involved with the experience rating of older adults. The present study provides the first evidence that these connectivities may underlie the perception of increased experience toward older targets. The function of these connectivities and implications are discussed.

1. Introduction

Failing to consider another person as having a mind capable of complex feelings and rational thought is a common problem in modern society. For instance, in 2016, a man killed 19 and wounded 26 disabled people in Sagamihara, Kanagawa Prefecture, Japan. The stated motive for the massacre was “It’s better that the disabled disappear,” and “There is no question I stabbed people who could not communicate well” (Kyodo, 2016). The man obviously failed to understand the communication abilities of disabled individuals. Another recent example involved a member of a Japanese government party who wrote that it is not appropriate to invest taxpayer money into policies supporting same-sex couples because “these men and women don’t bear children in other words, they are ‘unproductive’” (Osaki, 2018). These instances demonstrate the tendency to justify disrespectful behavior by perceiving other humans as less than human.

While the aforementioned instances are extreme forms of dehumanization, more subtle forms of dehumanization that do not involve hostility or overt dehumanization are also common. The most important example of the subtle form dehumanization is infrahumanization. Leyens and colleagues reported that people tend to view their in-group members as fully human whereas they consider many out-groups as less human. In their series of studies, participants attributed fewer unique human characteristics to out-group members (e.g., pride, love, embarrassment). Importantly, this phenomenon occurs spontaneously without explicit hostility (Leyens et al., 2000). In addition to the perception of social group (i.e., ingroup or outgroup), many other factors promote subtle dehumanization. For example, Hankel and colleagues found that consumers associated lower human quality with employees that work at discount stores (Hankel et al., 2018). They suggested that this subtle form of dehumanization associated with thrift-oriented brands could result in harsher employee treatment.

1.1. Consequences of dehumanization and humanization

Whether extreme or subtle, dehumanization has important social consequences. There is a link between humanity and morality; humanizing a person increases care toward the person whereas dehumanizing a person increases aggression toward the person. The psychologist Albert Bandura was the first to illustrate this process. In his study, participants played the role of supervisors and were told that the purpose of the study was to examine how punishment affects decision-making (Bandura et al., 1975). As a supervisor, participants were instructed to give an electric shock to decision-makers in another cubicle if they demonstrated poor problem solving. Before the task, Bandura manipulated the perceived humanness of the decision-makers by allowing participants to overhear a conversation among research staff about the decision-makers. In the humanized condition, participants overheard the decision-makers characterized as "perceptive and understanding." In the dehumanized condition, participants overheard the decision-makers characterized as “an animalistic, rotten bunch.” In the neutral condition, no evaluative references about the decision-makers were made. The participants administered the highest intensity of shocks to the dehumanized decision-makers and the lowest intensity of shocks to humanized decision-makers (Figure 1). This link between humanity and morality has been consistently replicated by other researchers. For example, perceiving an individual as less than human leads to behaviors such as discrimination (Albarello & Rubini, 2015) or aggression toward the target (Viki, Osgood, & Phillips, 2013). Conversely, perceiving an individual as fully human leads to better treatment, such as including those individuals in a moral community or empathizing with them (Haslam & Loughnan, 2014). Given the strong link between humanity and morality, it is important to examine the influences and consequences of the link because these examinations may reduce prejudice or prevent discrimination. Indeed, many researchers have explored the link between humanity and morality to understand its significance (Deska & Hugenberg, 2017; Deska, Lloyd, & Hugenberg, 2018; Hugenberg et al., 2016; Krumhuber, Lai, Rosin, & Hugenberg, 2019).

1.2. Two attributes of humanness perception

Previous behavioral studies have demonstrated that perceived humanness consists of two attributes: agency and experience (Gray, Gray, & Wegner, 2007; Gray, Jenkins, Heberlein, &

Wegner, 2011; Waytz, Gray, Epley, & Wegner, 2010). A study led by Gray and colleagues provided empirical evidence that people perceive humanness (mind) in these two distinct dimensions (Gray et al., 2007). In a large-scale survey, participants evaluated various capacities related to humanness in a variety of beings (e.g., adult humans, infants, gods). A factor analysis revealed that there were two factors of mind: (1) agency, which included seven capacities such as self-control, planning, and thought, and (2) experience, which included eleven capacities such as pain, pleasure, and joy. Adult humans were perceived to have both experience and agency, whereas babies were perceived to have experience only. Gods were seen as having agency only (Figure 2). Therefore, perceiving agency and experience in others represents the essence of humanness perception. Although other researchers have used different terms for these dimensions, the underlying concept of humanness perception is consistent. For example, Haslam and Bain argued that people perceive humanness based on two characteristics: human uniqueness, such as cognitive refinement and being cultured, and human nature, such as warmth and emotionality (Haslam, 2006; Haslam & Bain, 2007). These dimensions are similar to Gray's model in that both uniqueness and agency imply the capacity to plan and act, and both human nature and experience imply the capacity to sense and feel. Kozak and colleagues identified three factors underlying the perception of humanness: (1) emotion (e.g., ability to feel pain), intention (e.g., ability to do things on purpose), and cognition (e.g., ability to reason). These dimensions align with Gray's model because emotion is similar to experience and both intention and cognition are considered agency. Thus, agency and experience represent two attributes that are consistently described as key attributes of humanness perception.

1.3. 1.3. Perceived humanness varies with target characteristics

The degree of perceived humanness varies with a target's characteristics. Racial and/or ethnic difference is one of the most well studied characteristics given its importance. For example, past studies have found that white perceivers attribute less uniquely human ability (agency) to black targets (e.g., Costello & Hodson, 2014) and that Chinese and Anglo-Australian people attribute a lower degree of humanness to the other's group than they do to their own (Bain, Park, Kwok, & Haslam, 2009). Gender is also a factor influencing humanness perception. Focusing on women's appearance leads people to attribute less human nature (experience) to them (Heflick & Goldenberg, 2009; Heflick, Goldenberg, Cooper, & Puvia, 2011). In addition to race and gender, several studies have reported that perceived humanness is influenced by other characteristics, such as occupation (Loughnan & Haslam, 2007), social class (Loughnan, Haslam, Sutton, & Spencer, 2014), and preference (Kozak, Marsh, & Wegner, 2006).

The effects of a variety of characteristics on the perception of humanness have been examined. According to a review by Haslam and Stratemeyer, however, the effect of age, which is a primary characteristic in social cognition, has not been fully examined (Haslam &

Stratemeyer, 2016). Considering that age is an essential aspect of the classification of others (Berry & McArthur, 1986) and that older people have a high risk of being negatively stigmatized by stereotypes (Nelson, 2011), age likely influences the perception of humanness. Recently, the results of several studies have supported this prediction (Boudjemadi, Demoulin, & Bastart, 2017; Wiener, Gervais, Brnjic, & Nuss, 2014). For example, study participants considered age-derogated older workers as having been dehumanized (Wiener et al., 2014). In addition, younger people were found to implicitly associate animalistic words with older people, and they attributed lower uniquely human ability to older people (Boudjemadi et al., 2017). To my knowledge, the effect of age on the perception of humanness has not been evaluated. Furthermore, the correlation between neural activity and perceived humanness of different aged targets is unknown.

1.4. Studies examining the neural basis of humanness perception

Even fewer studies have examined the neural basis of the perception of humanness than have focused on behavioral results. In several preliminary studies, participants viewed two types of images broadly perceived as disgusting (e.g., homeless people and drug addicts) or not disgusting (e.g., college students and business people) in an MRI scanner (Harris & Fiske, 2006, 2007). When participants viewed the images considered disgusting, their medial prefrontal cortex (mPFC) was less activated than when they viewed the non-disgusting images (Harris & Fiske, 2006, 2007). The researchers interpreted the activity of the mPFC as reflecting dehumanization toward perceived disgusting groups at the neural level, because the mPFC is an index of social cognition (Amodio & Frith, 2006). Given the significance of the mPFC in social cognition (Saxe, 2006), it is possible that the activation of the mPFC linearly correlates with a degree of perceived humanness. Harris and Fiske reported a ventral and dorsal mPFC distinction when inferring individuating information (i.e., food preferences) for extreme outgroups and non-outgroups (Harris & Fiske, 2007). When inferring preferences of extreme outgroups, the dorsal mPFC was activated, while the ventral mPFC was activated when inferring preferences of non-outgroups. Thus, distinct mPFC regions (i.e., ventral and dorsal) may differentially influence the perception of humanness perception based on the targets' characteristics (i.e., outgroup or non-outgroups). In addition to the mPFC, studies investigating the neural activities of dehumanization reported that left-lateralized activity plays a significant role in the perception of humanness (Bruneau, Jacoby, Kteily, & Saxe, 2018; Jack, Dawson, & Norr, 2013). Jack and colleagues asked participants to rate their feelings when viewing a human image with an audio story in an MRI scanner. The audio story was designed to link/distance the human to/from either animals or machines (Jack et al., 2013). The results showed increased left lateralized activity (e.g., in the left precentral sulcus) in response to a human linked with either animals or machines. More recently, Bruneau and colleagues also investigated the specific role of the left lateralized brain region; the left inferior parietal gyrus (IFG), in particular, showed significant activation during dehumanization ratings (Bruneau et al., 2018). In their study, participants gave dehumanization ratings to social groups (e.g., Americans, Muslims, and the homeless) in an MRI scanner. The left IFG was parametrically associated with dehumanization ratings even when controlling for other similar ratings (e.g., dislike and dissimilarity ratings).

As mentioned above, only a few studies have examined neural activity when subjects perceived dehumanized groups. However, even fewer have examined neural activity when humanizing specific targets (i.e., older people). The present study had two key objectives: (1) to examine the effect of target age on the perception of humanness and (2) to evaluate neural activity associated with humanizing older and younger targets. This study has been submitted to a scientific peer-reviewed neuroimaging journal (Saito et al., 2019).

1.5. Hypothesis development

The present study is the first to use fMRI to investigate the effect of age on perceived humanness. Based on prior behavioral studies, I proposed the following two hypotheses regarding the behavioral results. First, the agency of older people might be perceived as lower than that of younger people because older people are stereotyped as incompetent and dependent

(Cuddy, Norton, & Fiske, 2005). Indeed, older people are often associated with cognitive decline, such as memory difficulties and reasoning failure (Branch, Harris, & Palmore, 2005). Second, the experience of older people might be perceived as higher than that of younger people because older people are stereotypically considered warm and tolerant (Cuddy et al., 2005; Fiske, Cuddy, Glick, & Xu, 2002).

Based on a previous study, I also proposed the following two hypotheses regarding neural activity when people humanize a target. First, I hypothesized that the mPFC would parametrically correlate with humanization ratings because the mPFC plays a significant role in social cognition (Harris & Fiske, 2006, 2007). Second, the left IFG would negatively correlate with humanization ratings because this region positively correlates with dehumanization judgments (Bruneau et al., 2018; Jack et al., 2013), and humanization ratings are conceptually opposite to dehumanization ratings. Furthermore, I investigated functional connectivity with these brain regions (the mPFC and IFG) as seed regions. I conducted functional connectivity analyses because these can provide important information for understanding the fundamental organization of processing systems in the human brain (Cole, Smith, & Beckmann, 2010).

2. Methods

2.1. Participants

I recruited 40 undergraduate and graduate students as participants. After I explained the purpose and procedure of the current study, I obtained written informed consent from each participant. They received ¥3,000 (about $30) for their participation. The participants were recruited by the university bulletin board and mailing list. All participants had normal or corrected-to-normal vision and no history of neurological or psychiatric illnesses. The participant characteristics were evaluated using questionnaires related to humanness perception: the Fraboni Scale of Ageism (Harada et al., 2004), the UCLA Loneliness Scale (Russell, 1996), and the Need to Belong Scale (Leary et al., 2013). All participants scored within 2 standard deviations (2SD) of the mean response for each questionnaire (Appendix Table 1). The data of five participants were excluded due to technical issues in which the MRI machine failed to collect brain data completely. Finally, data from 35 participants (13 females, $mean_{age}$ = 20.54 years, SD_{age} = 1.63) were analyzed. This study was approved by the Ethical Committee of the School of Medicine at Tohoku University and was conducted in accordance with the Declaration of Helsinki.

2.2. Stimuli

A total of 160 face images from websites, 80 older faces (40 females, 40 males) and 80 young faces (40 females, 40 males), were included as targets for the current study. First, my collaborator chose 556 facial images without salient features (e.g., beard, glasses, piercings, and tattoos). All face images were license-free and looked to the front. The background was removed to standardize the images. The images were converted into 256 × 256-pixel grayscale images with white backgrounds. Ten participants evaluated the age of each face with an 8-point scale from 1 (teens) to 8 (eighties). Based on the ratings, I selected 80 older faces (most evaluated as > 60 years old) and 80 younger faces (most evaluated as < 30 years old). At this time, we excluded faces with obvious facial expressions, such as smiling, to reduce the effect of facial expression on participant responses. To control for the attractiveness of older and young faces, I asked 19 independent participants to rate the images on a 4-point Likert scale from 1 (less attractive) to 4 (highly attractive). Based on their ratings, I selected 80 images (40 older faces, 40 young faces) for inclusion in the present experiment. The gender ratio of the images was equal (i.e., female:male = 1:1). The mean attractiveness-rating scores for the selected 80 images were 2.67 (SD = 0.30) for older faces and 2.74 (SD = 0.23) for younger faces. The attractiveness scores of the groups were not significantly different ($t(78) = 1.24$, $P = 0.22$, *n.s.*).

2.3. Experimental task

I programmed and conducted experimental tasks with PsychoPy version 1.85.2 (Peirce, 2007). All stimuli were presented on a 32″ LCD monitor with an LED backlight intended to display visual stimuli for fMRI experiments (BOLDscreen 32; Cambridge Research Systems, UK). Participants indicated their response with a four-button response pad (HHSC-2×4-C; Current Designs, Inc., Philadelphia, PA, USA).

The experimental session comprised four tasks in which agency, experience, attractiveness, and belonging were rated. Participants were provided instructions before each task. The following instructions were used for each task: (a) the agency task: "Please indicate the extent to which you feel a target has agency, which is the capacity to plan and act;" (b) the experience task: "Please indicate the extent to which you feel a target has experience, which is the capacity to sense and feel pain and emotions such as pride;" (c) the attractiveness task: "Please indicate how attractive you find the target;" and (d) the belonging task: "Please indicate the extent to which you think the target would accept you." Because the agency and experience concepts were unfamiliar to participants, we provided specific examples for clarity. The following explanation was provided: "Agency is the capacity to plan and act and experience is the capacity to sense and feel pain and emotions such as pride. Please imagine a baby and an android. The baby is capable of feeling and sensing, but not planning and action. In this case, the baby has experience but not agency. On the other hand, the android is capable of action, but not feeling. In this case, the android has agency but not experience." These explanations for agency and experience were adapted from previous studies (Gray et al., 2007; Haslam, 2006). After viewing a fixation cross as an interval jitter for either 2 s, 4 s, or 6 s (frequency weighted 2, 1, 1, respectively), participants saw a face for 4 s (Figure 3). During the face viewing time, they indicated their answer by pressing a button according to a 6-point Likert scale from 1 (not at all) to 6 (very much). Similar to previous studies, a Likert scale was used to rate humanness perception (agency and experience) because humanness perception is theoretically a continuous variable (Deska et al., 2018). In each task, they viewed 40 older and 40 younger faces. In total, they viewed 80 faces four times. The order of presentation of the faces was randomized in each task.

2.4. Procedure

Before the experiment, I provided instructions regarding the experimental tasks. Then, participants practiced responding to the questions using the four-button response pad. The scanning session consisted of four runs. In each run, participants completed an experimental task in which they had to rate 80 face images. Each run took about 10 min. After two runs (e.g., the experience and agency tasks), participants took a 20-min break outside of the MRI scanner. Then, participants did the remaining two experimental tasks (e.g., the attractiveness and belonging tasks) as the third and fourth runs. After four runs, I acquired T1-weighted 3D volume scans for about 10 min. The order of tasks was pseudo-randomized across participants.

2.5. Imaging procedure

All fMRI data were acquired with a 3T Philips Achieva scanner (Philips Healthcare, Best, The Netherlands) at the Institute of Development, Aging and Cancer of Tohoku University. Functional images were acquired using a whole-brain continuous dual-echo sequence (TR = 2,000 ms, TE = 12 and 35 ms, flip angle = 90°). In each run, 304 volumes were acquired.

For each participant, a high resolution T1-weighted 3D volume scan was acquired with the MPRAGE sequence (field of view = 240 mm, flip angle = 88°, matrix size = 240 × 240, TR = 6,500 ms, TE = 3 ms, 162 slices, 1.0 mm slice thickness).

2.6. Behavioral data analysis

Analyses of the behavioral data were conducted using R software (R Core Team, 2019). I examined the effect of target age on the perceived humanness ratings (i.e., agency and experience) using a generalized linear mixed model (GLMM). For the GLMM analysis, I used the lme4 package (Bates, Mächler, Bolker, & Walker, 2015) and standardized all variables. Therefore, I reported standardized beta values in the Results section. The dependent variables were agency and experience rating. The fixed effect was target age (1 = older, 2 = younger). The random effects were participants and face images. The attractiveness and belonging ratings were included as covariates.

2.7. fMRI data analysis

The fMRI data were analyzed using SPM12 (https://www.fil.ion.ucl.ac.uk/spm/software/spm12/) implemented in MATLAB 2017a (www.mathworks.com). The fMRI data preprocessing was carried out according to the following procedures. First, the functional images were realigned. Then, slice-timing correction was applied to the images. Subsequently, the images were coregistered to each participant's MPRAGE image (T1 image) and spatially normalized to the Montreal Neurological Institute (MNI) template. Finally, the functional images were smoothed using a Gaussian kernel with an 8-mm full width at half-maximum.

I used a multi-stage general linear model approach to analyze the fMRI data. At the individual level, I estimated trial-related activity separately for each run and participant. Trials with no responses were omitted from the analysis. To examine the brain regions in which activity linearly correlated with rating scores for agency, experience, attractiveness and belonging tasks, the scores were entered into the model as first-order parametric modulators. The entered rating scores were transformed (i.e., 1, 2, 3, and 4) from the original scores (i.e., 1, 2, 3, 4, 5, and 6) to reduce the number of missing values. I grouped original scores of 1 and 2 and scores of 5 and 6; thus, the original scores were transformed from 1 and 2 to 1, 3 to 2, 4 to 3, and 5 and 6 to 4.

At the group level, I used a two-factorial design with a factor for target age (older and younger) and a factor for condition (agency, experience, attractiveness, and belonging) in SPM12 to identify a specific activation pattern. The statistical threshold for imaging results was set to $P < 0.001$ and was family-wise error (FWE) corrected for multiple comparisons at the cluster level $P < 0.05$.

Given my a priori hypotheses that both the left IFG and the mPFC were involved, I conducted additional connectivity analyses (seed-to-voxel analyses) using the CONN toolbox version 18b (http://www.nitrc.org/projects/conn). For the connectivity analysis of the mPFC, I set the ventral part of the mPFC as a seed because there is ventral–dorsal distinction in the mPFC (Harris & Fiske, 2007; Mitchell, Banaji, & Macrae, 2005). The connectivity analyses correlated the time series of the seed region, ventral mPFC, and left IFG with the time series of all other regions to investigate significant functional connectivity with the seed region. I defined the seed regions based on the Harvard–Oxford Cortical Atlas in the CONN toolbox. The statistical threshold for the connectivity analysis was set to $P < 0.05$, and FWE-corrected for cluster size.

3. Results

3.1. Behavioral data

Tables 1 and 2 show the means and standard errors of ratings and response times. I collected 10,984 responses from all participants (2,829 responses for score 1; 3,516 for score 2; 2,678 for score 3; and 1,961 for score 4). I conducted GLMM analyses to assess the effect of target age on ratings of perceived humanness. I found a significant effect for target age on experience rating ($\beta = -0.062$, $z = -2.350$, $P = 0.021$). This significant effect remained when participant's sex was included as a covariate in the model. Thus, gender differences did not significantly influence the experience rating. This result indicates that older targets were perceived as having more experience than younger targets. On the other hand, there was no significant effect on agency rating ($\beta = 0.007$, $z = 0.200$, $P = 0.842$, *n.s.*). This effect remained after inclusion of the participant's sex as a covariate. The results for the behavioral data suggest that target age differentially influenced two distinct dimensions of perceived humanness.

I conducted GLMM analyses to assess the effect of target age on response times during the perceived humanness rating tasks. I found no significant effect on either experience or agency ratings ($\beta s = 0.022, 0.016$; $z = 1.530, 0.311$; $P = 0.123, 0.311$, *n.s.*). I also examined the neural correlations from the analyses of fMRI the data, which can elucidate the underlying basis for differences in perceived humanness due to target age.

3.2. fMRI data

I determined whether rating the perceived humanness of older and younger targets resulted in distinct patterns of neural activation compared with other similar ratings. There were condition-related neural activities for each condition (agency, experience, attractiveness, and belonging) (Table 3). The postcentral gyrus activated in all conditions, whereas the cerebellum activated during agency and belonging ratings. Because the postcentral gyrus is involved in sensory processing of somatic stimuli (Mountcastle, 2005), the neural activities reported here may reflect tactile movements, such as pressing a button. Therefore, inconsistent with my expectation, I found no brain regions that correlated with the rating of the perceived humanness, either positively or negatively. Although I found a significant main effect for target age, there were no significant simple effects for target age in any condition. However, there was greater activity in the left IFG (pars opercularis) when participants made judgments toward older targets.

I assessed brain activities in regions with previously demonstrated involvement in humanness perception, the left IFG and the ventral mPFC. I extracted parameters of brain activity for each condition and each participant (Table 4). The results were seemingly consistent with previous findings and behavioral results of the current study. The left IFG (associated with dehumanization) deactivated more when evaluating experience of older targets (mean = −0.043) than younger targets (mean = −0.005). Importantly, more than half of participants followed this trend (20 out of 35 participants). The activity of the ventral mPFC (associated with humanization) was stronger when evaluating experience of older targets (mean = 0.041) compared with younger targets (mean = 0.033). More than half of participants followed this trend (20 out of 35 participants). These activation changes were consistent the behavioral test results, which showed that older targets were perceived to have more experience than younger targets.

3.3. Functional connectivity data

To identify distinct functional connectivity among each rating (agency, experience, attractiveness, and belonging), I conducted functional connectivity analyses. The left IFG and the mPFC were set as seeds. No significant functional connectivities were observed. In addition, no significant functional connectivities were identified in evaluations of older targets.

Although no significant functional connectivities were identified with respect to ratings, there were functional connectivities underlying the perception that older targets have higher experience. I performed seed-to-voxel analyses with the ventral mPFC and the left IFG as seeds (Table 5). First, I compared the neural connectivities of the ventral mPFC seed associated with experience ratings of older and younger targets. A significant cluster was located in the dorsal mPFC, which included the left and right medial superior frontal gyrus (SFG), and the dorsal anterior cingulate gyrus (dACC) showed significant negative connectivity with the ventral mPFC (Figure 4).

Second, I compared the neural connectivities of the left IFG seed associated with experience ratings of older and younger targets. The results showed increased connectivity between the left IFG and both the supramarginal gyrus and the postcentral gyrus. These findings suggest that functional connectivities of the ventral and the dorsal mPFC, as well as the IFG and the left supramarginal gyrus, modulated the degree to which target age affected the perceived humanness of targets.

4. Discussion

4.1. Summary of findings

The present study provides the first evidence that connectivities between the ventral and dorsal mPFC, as well as the left IFG and the supramarginal gyrus, underlie the perception of increased experience toward older targets.

In the present study, I investigated neural activity when people perceived the humanness of older and younger targets. Participants judged two aspects of humanness (agency and experience) and two other characteristics (attractiveness and belonging) for older and younger target faces in an MRI scanner. I hypothesized that older targets would be perceived as having less agency but more experience than younger targets, and that the mPFC and the left IFG would parametrically correlate with perception of humanness. I found that the perception of experience was influenced by target age. Participants rated older targets as having more experience than younger targets. Subsequent fMRI analyses revealed that different functional connectivity between the ventral and dorsal mPFC, as well as between the left IFG and both the supramarginal and postcentral gyrus, may underlie the differences in experience rating due to target age. However, inconsistent with my expectations, I did not find any brain regions related to humanization judgments.

4.2. The effect of target age on perceived humanness

Consistent with my hypothesis, participants rated the experience of older adults higher than that of younger adults. The results may reflect existing stereotypes that older people tend to be warm and tolerant (Cuddy et al., 2005; Fiske et al., 2002). However, importantly, the results did not support the hypothesis that the agency of older people is perceived as lower than that of younger people. A previous study focusing on dehumanization of older people reported that they were animalistically dehumanized (Boudjemadi et al., 2017). Such dehumanization could be a failure to perceive the agency of a target, as individuals were linked to animals when they were seen as lacking uniquely human abilities (agency), such as self-control, rationality, etc. (Haslam & Loughnan, 2014). Thus, the current result appears inconsistent with prior research reporting animalistic dehumanization of older people (Boudjemadi et al., 2017). The experimental settings between the previous and present study were quite different, which may explain why there was no significant difference in perceived agency between older and younger targets. Boudjemadi and colleagues used multiple approaches to assess the degree of animalistic dehumanization of older adults (Boudjemadi et al., 2017). In most of their experiments, participants responded with a dehumanizing attitude toward typical older people but not toward an older person individually. By contrast, in the present study, participants judged the humanness of each older adult when viewing their faces individually. When people see another person as an individual rather than part of a group, they tend not to link the person to a stereotype (Kunda & Sherman-Williams, 1993; Nelson, 2015) because information about an individual allows people to rely less on stereotypes. This may explain why participants did not give older people lower agency ratings in this study.

4.3. Functional connectivity when judging experience of older adults

I found functional connectivity between the ventral and dorsal mPFC when participants rated the experience of older targets. Previous research has suggested a ventral–dorsal distinction within the mPFC (Harris & Fiske, 2007; Mitchell et al., 2005). In one study, when participants inferred the preference of a target who elicited exclusively social emotions (pity, envy, or pride), a ventral area of the mPFC showed greater activation. Conversely, a dorsal area of the mPFC showed greater activation when participants inferred the preference of a target who did not elicit such social emotions (Harris & Fiske, 2007). Another study found that ventral mPFC activity correlated with the target's similarity to self, whereas the dorsal mPFC activity correlated with the target's dissimilarity to self when participants mentalized the targets (Mitchell et al., 2005). Considering these findings, the negative connectivity between ventral and dorsal mPFC in the present study may reflect the social distance between the participants and the targets. Older people who were targets in the current study were somehow perceived as an outgroup by the participants. Thus, the activation of the dorsal mPFC caused by an outgroup member (i.e., older people) may have been deactivated by the ventral mPFC when participants perceived the humanness of the target. It is worth focusing on the left SFG, which is a specific subregion in the dorsal mPFC. According to the review by Beer and Ochsner, the left SFG is a region associated with social knowledge, person-inferences, and person-representation (Beer & Ochsner, 2006). For example, people showed greater activity in the left SFG when they made semantic judgments about objects than when they did the same about people (Mitchell, Heatherton, & Macrae, 2002). Furthermore, activities in the left SFG have been observed when participants made empathic judgments (Farrow et al., 2001). Given that the left SFG showed greater activity for object judgments than those for people (Mitchell et al., 2002), the negative connectivity between the mPFC and the left SFG may reflect the role played by the ventral mPFC in deactivating the left SFG, which may correlate with objectifying.

In addition to the connectivity of the ventral mPFC, I also observed significant connectivity between the left IFG and both the left supramarginal gyrus and left postcentral gyrus. It seems natural that the supramarginal gyrus showed significant connectivity because the left parietal lobe, including the supramarginal gyrus, is associated with general social cognition processing, e.g., the theory of mind (Bzdok et al., 2016). If the activation of the left IFG negatively correlates with the perception of humanness, the activation of the supramarginal gyrus, which had positive functional connectivity with the left IFG, may be compensating for dehumanized perception toward older people. The left postcentral gyrus, which was also included in the cluster, is located in the primary somatosensory cortex. Although the function of the postcentral gyrus (i.e., sensory processing of somatic stimuli) is well known (Mountcastle, 2005), it is difficult to speculate the role of the left primary somatosensory cortex in perceiving humanness. However, considering that the left primary somatosensory cortex shows activation when encoding social information, such as the visual sex of a caress (Gazzola et al., 2012), it is possible that the left primary somatosensory cortex plays a role in the perception of humanness. Further studies will be needed to examine the role of the left primary somatosensory cortex in social cognition.

4.4. Limitations, future studies, and implications

The present study has several important limitations. First, although a variety of target groups (e.g., Gypsies, Muslims, and Europeans) have been used previously (Bruneau et al., 2018), I used specific stimuli of two target groups (younger and older targets) after controlling for perceived attractiveness. My stimuli were advantageous for examining the unique neural activities because they controlled for potential confounding factors such as differences in race or attractiveness. However, it is possible that the limited variation in stimuli resulted in little variation in neural activities. Thus, I may not have elicited significant activity for each judgment.

Further research using a variety of stimuli is needed to confirm this. Second, my primary purpose was to examine the effect of age on perceived humanness; however, I recruited only younger people as participants. The effect of age on the perception of humanness may be affected by the perceiver's own age. Indeed, more recent studies have explored the effect of the perceiver's state on social cognition (Saito, Motoki, Nouchi, Kawashima, & Sugiura, 2019) and consumer behavior (Motoki, Saito, Nouchi, Kawashima, & Sugiura, 2018). According to Hehman and colleagues, the interaction between the perceiver and target plays a large role in impression formation (Hehman, Stolier, Freeman, Flake, & Xie, 2019; Hehman, Sutherland, Flake, & Slepian, 2017). Further studies recruiting both older and younger targets are necessary to consider the effect of age on perception of humanness. Third, the explanation provided to clarify agency and experience may have biased participants' responses. Although this explanation helped convey the concept of both agency and experience by providing specific examples (baby and android), features of examples (e.g., young age of baby) may have led participants to report less agency of faces having young features. Perhaps the greatest limitation of the present study is that I interpreted the functional connectivities as contributing to greater experience evaluation. However, it is possible that the observed functional connectivities simply represent the age differences of targets since brain activities regarding experience evaluation were compared between older and younger targets. To test the validity of my interpretation, future studies should evaluate whether the functional connectivities genuinely influence experience evaluations, regardless of target age.

5. Implications

I believe that this study has implications for improving medical and nursing services. Excessive dehumanization of outgroup people can lead to aggression towards them (Viki et al., 2013), whereas healthcare workers who humanize patients risk burning out with their work (Vaes & Muratore, 2013). Thus, how people perceive the humanness of targets with different characteristics, such as patients and the elderly, at both the behavioral and neural levels, is of great importance. The present work suggests that the neural connectivities of the mPFC and the left IFG play a role in increasing the perceived experience of older people. Perceived experience is important for being afforded moral rights (Gray et al., 2007; Waytz et al., 2010). Thus, it may be possible to provide insights into how people in the medical or nursing fields attribute appropriate humanness to their patients from the perspective of neural mechanisms. For example, a precise evaluation of the perception of humanness by medical workers toward their patients may provide valuable insight regarding situations that influence workers perception of patient humanness. Moreover, the findings reported here will inform education programs aimed at increasing humanness perception toward others by providing a method to quantify the degree of humanness perception toward others.

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Figures and Tables

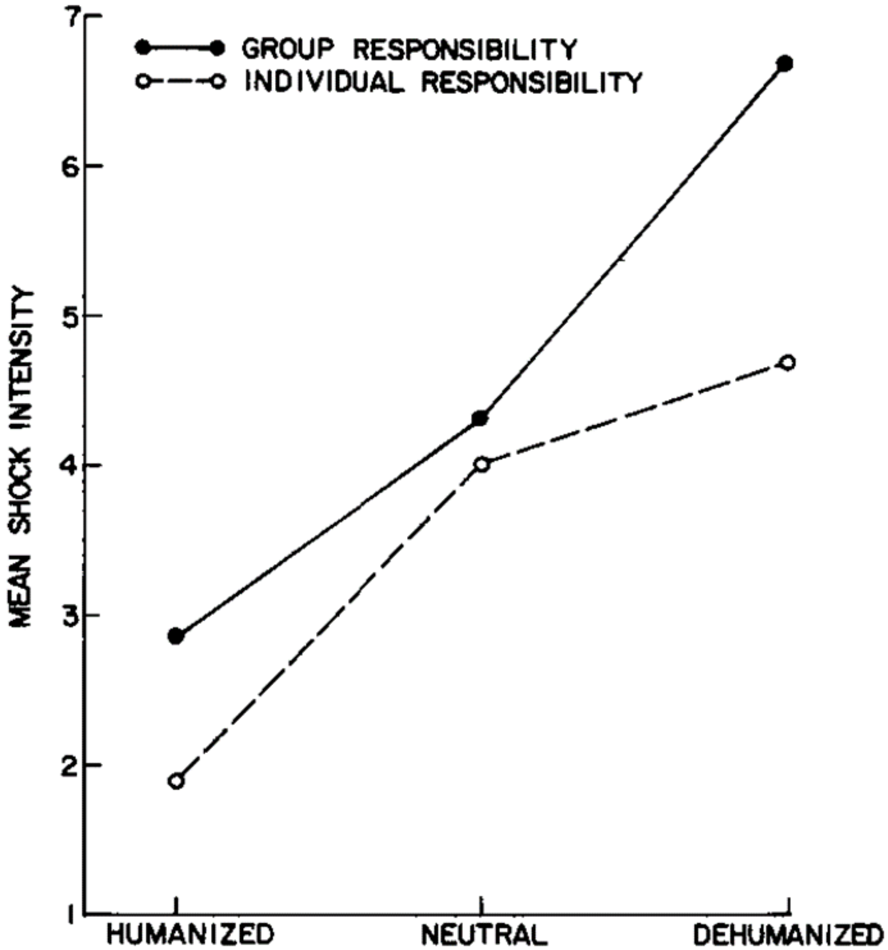

Figure 1. Mean intensity of shocks administered by participants as a function of dehumanization of the recipients in Bandura et al.'s 1975 experiment.

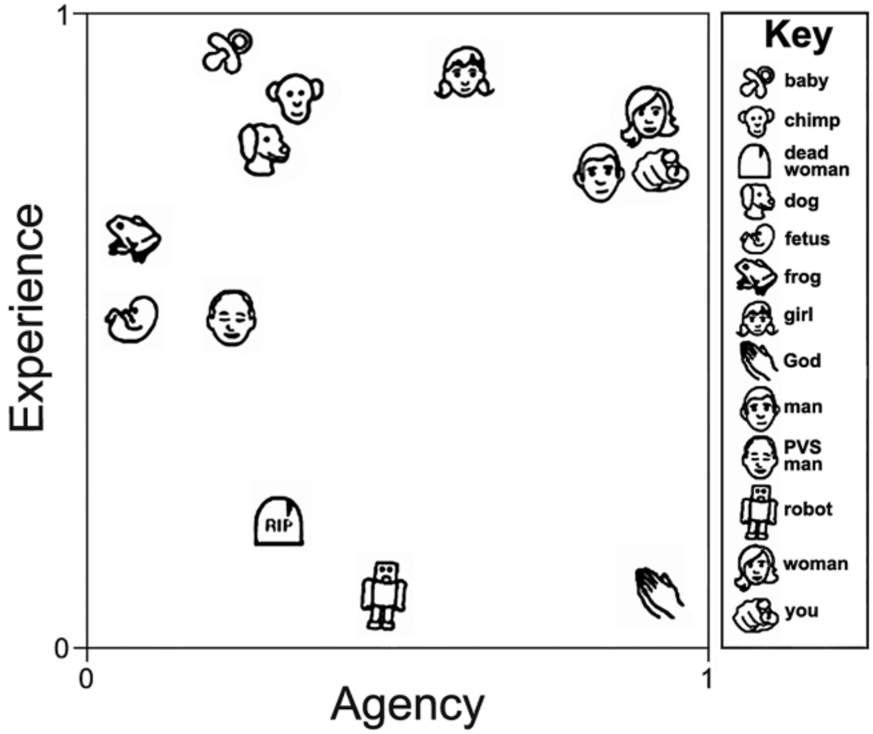

Figure 2. Perceived agency and experience capacities of each character assessed in Gray et al.'s 2007 experiment.

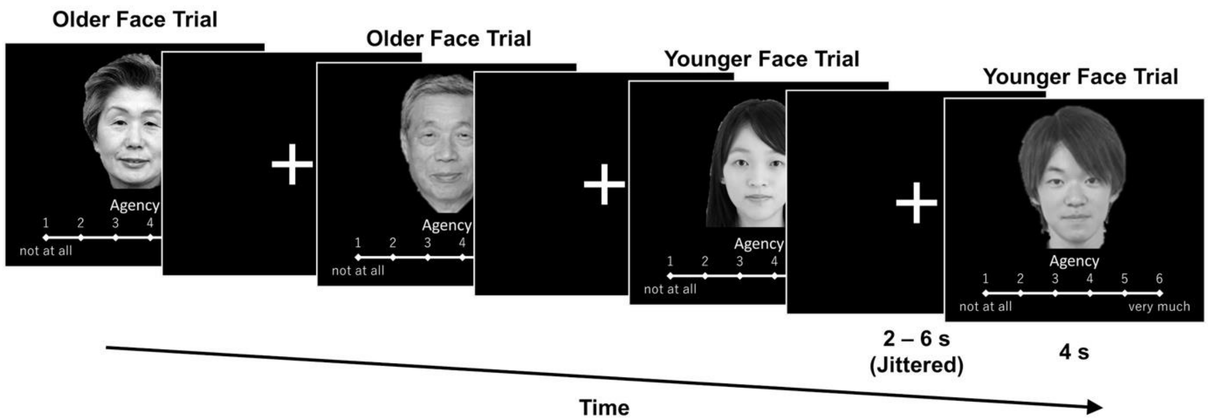

Figure 3. An example of older and younger faces used in the experimental agency task. The order of stimuli was randomized across participants.

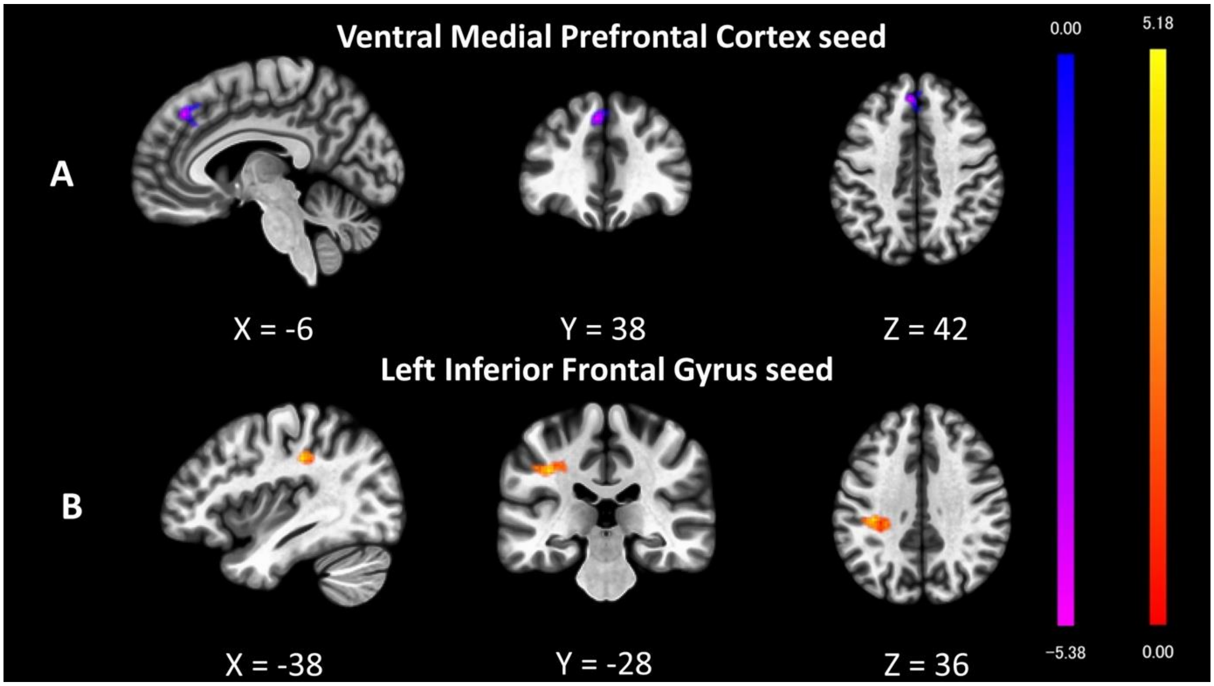

Figure 4. Clusters showing functional connectivity with seed regions in a comparison of experience ratings for older and younger targets. (A) Significant cluster showing significant negative connectivity with the ventral mPFC. (B) Significant cluster showing significant negative connectivity with the left IFG.

Table 1. Mean value and standard error (S.E.) for each rating.

	Older		Younger	
Variable	*Mean*	*S.E.*	*Mean*	*S.E.*
Experience	3.516	0.128	3.496	0.112
Agency	3.446	0.116	3.631	0.088
Attractiveness	2.701	0.119	3.427	0.099
Belonging	3.063	0.089	3.249	0.087

Table 2. Mean response time and standard error (S.E.) for each condition.

	Older		Younger	
Variable	*Mean*	*S.E.*	*Mean*	*S.E.*
Experience	2.078	0.072	2.105	0.073
Agency	2.098	0.071	2.118	0.072
Attractiveness	1.977	0.073	2.015	0.072
Belonging	2.089	0.073	2.152	0.077

Table 3. Group-level analysis of variance brain activity results.

Brain region involved with significant cluster	Peak coordinates of the cluster			Size	*t*-value	*P*-value (FWE-corrected in cluster size)
	x	y	z			
Main effect of age (older > younger)						
Inferior frontal gyrus (pars opercularis)	−60	8	28	21	4.88	0.019
Main effect of condition						
No significant activation						
Simple effect of agency						
Postcentral gyrus	44	−22	60	1105	9.03	0.001
Cerebellum	−24	−54	−26	15	4.73	0.025
Simple effect of experience						
Postcentral gyrus	44	−20	62	767	8.40	0.001
Simple effect of attractiveness						
Postcentral gyrus	38	−24	54	13	4.54	0.026
Simple effect of belonging						
Postcentral gyrus	42	−22	56	173	5.41	0.001
Cerebellum	−26	−50	−28	22	4.68	0.020
Simple effect of age for each condition (older > younger)						
No significant activation						
Simple effect of age for each condition (older < younger)						
No significant activation						

Table 4. Mean beta values in brain regions with reported roles in the perception of humanness.

Region				Agency				Experience			
				Old		Young		Old		Young	
	x	y	z								
left IFG	−51	15	15	0.029	(0.127)	−0.005	(0.177)	−0.043	(0.122)	−0.005	(0.123)
vmPFC	0	43	19	0.057	(0.199)	0.016	(0.246)	0.041	(0.196)	0.033	(0.151)

IFG = inferior frontal gyrus, vmPFC = ventral part of the prefrontal medial cortex, standard deviations are shown in parentheses.

Table 5. Functional connectivity comparisons for experience ratings of younger and older targets.

Seed	Brain regions in the significant cluster	Peak coordinates of the cluster			Size	*P*-value (FWE-corrected in cluster size)	*t*-value
		x	y	z			
vmPFC	dmPFC including SFG and dACC	−6	38	42	435	0.002	−5.51
left IFG	Postcentral gyrus and supramarginal gyrus	−38	−28	36	295	0.014	5.91

IFG = inferior frontal gyrus, vmPFC = ventral part of the prefrontal medial cortex, dmPFC = dorsal part of the prefrontal medial cortex, SFG = superior frontal gyrus, dACC = dorsal anterior cingulate cortex.

Appendix

Appendix Table 1. The mean participant response and standard deviation (SD) for psychological scales.

	Mean	SD
Ageism	65.81	22.04
Loneliness	38.63	15.16
Need to Belong	29.66	12.74

Note: Each participant's rating was summed for all questionnaires. Ageism ratings ranged from 1 to 5 ('agree' to 'disagree'). The range of summed scores was 19 to 95. Ratings of loneliness were on a 1 to 4 scale ('never' to 'always'). The range of summed scores was 20 to 80. Ratings of need to belong were on a 1 to 5 scale ('not at all' to 'extremely'). The range of summed score was 10 to 50.