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BRIEF COMMUNICATION

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Costs of reproduction are reflected in women's faces: Post-menopausal women with fewer children are perceived as more attractive, healthier and younger than women with more children

Urszula M. Marcinkowska[1] | Anthony C. Little[2] | Andrzej Galbarczyk[1] | Ilona Nenko[1] | Magdalena Klimek[1] | Grazyna Jasienska[1]

[1]Department of Environmental Health, Faculty of Health Sciences, Jagiellonian University Medical College, 20 Grzegorzecka St., PL 31531, Krakow, Poland

[2]Department of Psychology, University of Bath, Claverton Down, Bath FK9 4LA, United Kingdom

Correspondence
Andrzej Galbarczyk, Institute of Public Health, Jagiellonian University Medical College, Grzegorzecka 20 St., PL 31531 Krakow, Poland.
Email: agalbarczyk@gmail.com

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Abstract

Objectives: The costs associated with reproduction (i.e., gestation, lactation, childcare) have long-term negative consequences by elevating risk of disease and reducing lifespan. We tested the hypotheses that high parity, and thus high reproductive costs bear by women, is perceived by other people when they evaluate facial appearance of health, attractiveness and age of mothers.

Materials and Methods: Using computer software we created average facial images based on real photographs of post-menopausal women with varying number of children; 3 parity categories were created (1–2, 4–5, and 7–9 children). Study participants ($N = 571$) were asked to choose the face they perceived as more attractive, younger and healthier via two-alternative forced choice questions asked in three randomized blocks.

Results: Women who had given birth to fewer children were judged both by men and women as more attractive, younger and healthier than women with more children. In each category the lowest scores were received by women from highest parity category (7–9 children).

Discussion: Mechanisms behind the observed variation in facial appearance are not known but higher levels of oxidative stress among women with high parity may explain their faster aging and lower attractiveness in older age. These results suggest that costs of reproduction might affect women's physical appearance.

KEYWORDS
aging, evolutionary medicine, evolutionary psychology, facial perception, parity

1 | INTRODUCTION

Human faces provide cues to health status and are important in mate choice (Perrett, 2012). Facial features are indicators of age (Burt & Perrett, 1995), health (Gray & Boothroyd, 2012), parenting skills (Boothroyd, Jones, Burt, & Perrett, 2007), and dominance (Perrett, Lee, & Penton-Voak, 1998). These features have genetic components, but they are also shaped throughout life. For example, environmental stressors during development may affect homeostatic effectiveness (via metabolic, hormonal and immunological perturbations) (Watson & Thornhill, 1994). This may lead to random deviations from bilateral symmetry (facial asymmetry) (Watson & Thornhill, 1994) and, consequently, to lowered attractiveness (Grammer & Thornhill, 1994). Metabolic, hormonal and immunological changes are also caused by reproduction. Pregnancy, lactation and childcare require high expenditure of energy and increased nutrients intake, therefore, women with high parental investment, resulting from multiple pregnancies (high parity) often have higher risk of diseases and a reduced lifespan (Jasienska,

2009; Jasienska, Nenko, & Jasienski, 2006). Poor health in women with high parity may result from long-term changes in immune system (Marttila et al., 2015) and higher levels of oxidative stress (Ziomkiewicz et al., 2016)—a main factor contributing to body's deterioration with progressing age (Finkel & Holbrook, 2000). Further, genes with antagonistic pleiotropic effects (i.e. encoding traits that increase fertility but also increase a risk of health problems) may contribute to the phenomenon of poorer health and shorter lifespan in women with high parity (Jasienska et al., 2015).

This study, based on real life photographs of a group of post-menopausal women who had variable parity (from 1 to 9 children) tested the hypothesis that in women high parity, and thus high reproductive costs, are related to differences in facial appearance in health, attractiveness and age that are perceived by others. We predict that women with higher parity are perceived as less healthy, less attractive and older than women with lower reproductive costs. This would suggest that humans are equipped with domain-general cognitive tools to perceive somatic state not only of potential mating partners, but also of older age, post-reproductive individuals.

2 | MATERIALS AND METHODS

Women whose pictures were used for visual stimuli creation were recruited as a part of a larger study ($N = 327$), during home visits performed by trained study assistants. Women from our larger study had 10.5 (SD = 3.42) years of education and 3.9 (SD = 2.12) children on the average. Their mean age at marriage was 23.5 (SD = 4.74), age at first birth was 24.0 (SD = 3.94) and their reproductive lifespan was 9.8 (SD = 5.27) years. They were all post-menopausal, lived in a village, came from a relatively homogenous, in terms of lifestyle and socioeconomic status, rural community in southern Poland (Jasienska, 2013) and were involved in agricultural work, either as their major occupation, or by helping parents or extended family. Most of the women did not work professionally, allocating their time to housework, agricultural work and childcare. As compensation for participation in the study women received books and a framed photograph of themselves. Original pictures of women were taken under standardized conditions.

Out of all participating women, photographs from 30 were randomly chosen to create visual stimuli. Depending on the number of children, women were classified into three Parity Categories (ParCat): Low (1 or 2 children), Medium (4 or 5 children), High (7 to 9 children). Using the computer graphics program Psychomorph, two composite images per each ParCat were created (each based on five real life base pictures), both capturing the shape and color of the constituent images (Tiddeman, Burt, & Perrett, 2001) (see Figure 1 for examples). Composite images were created in a way to constitute an exact average representation of shape, color, and texture of all base (real life) pictures. The average age of the women from the base pictures used for each composite ranged from 64.0 to 66.1 years. By using approximate age-matching for the images we ensured that average ages were not significantly different between each ParCat ($F_{(2,\ 27)} = 0.01$, $p = .996$) and between composite pictures ($F_{(5,\ 24)} = 0.02$, $p = .999$). We also controlled for education, which is a reliable indicator of the socioeconomic status in this studied population (Colleran, Jasienska, Nenko, Galbarczyk, & Mace, 2014). Average number of years of education was not significantly different among Parity Categories ($F_{(2,\ 27)} = 0.99$, $p = .386$) and among composite pictures ($F_{(5,\ 24)} = 0.65$, $p = .661$). There were also no significant differences in average age at first reproduction between women from each ParCat ($F_{(2,\ 27)} = 1.03$, $p = .371$) and from each composite picture ($F_{(5,\ 24)} = 1.07$, $p = .401$).

Four hundred fifty four heterosexual women (aged 17–73, mean = 28, SD = 8.2) and 117 heterosexual men (aged 17–73, mean = 28, SD = 9.1) completed an on-line survey that consisted a socio-demographic part and a slide show with composite images. The survey has been advertised in social media (e.g. Facebook) as a "facial perception study." In three blocks, participants were asked via 2—alternative forced choice questions to choose from each pair the face they perceived as (i) more attractive, (ii) healthier, and (iii) younger. Each block consisted of six questions depicting two out of three ParCats (each composite picture was shown twice). Order of blocks, order of pictures and localization of pictures (left or right hand side of the screen) were randomized.

We calculated the number of times the face representing a woman with fewer children (score = 0) was chosen over the face of woman

FIGURE 1 Examples of composite average face images of each of the parity categories representing the mean facial shape and color. Left: Low Parity, middle: Medium Parity, right: High Parity

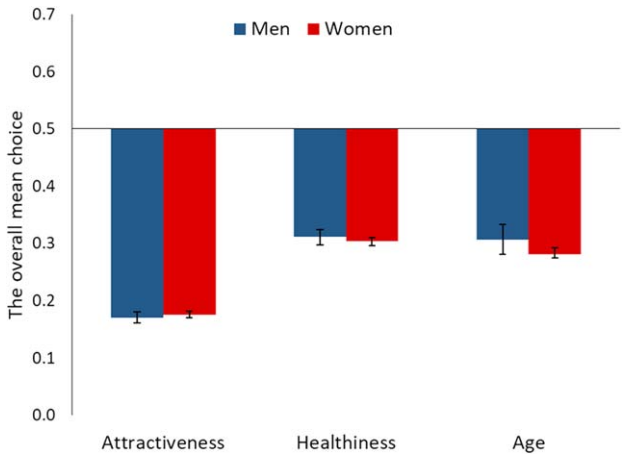

FIGURE 2 The overall mean choice of face representing women with fewer children, with 95% CI. Averaged faces of women with fewer children were judged (both by men and women evaluators) to be more attractive, healthier and younger more often than faces of women with more children

with more children (score = 1) for each participant. The overall mean choice of face representing women with more children was calculated. Means were also calculated separately for each comparison among the three ParCats (Low vs. Medium, Medium vs. High and Low vs. High). Mean higher than 0.5 indicates preference for faces of women with more children and below 0.5 indicates preference for faces of women with fewer children.

3 | RESULTS

The overall choice of face representing women with fewer children was analyzed with a one-sample t-test against chance (0.5). Composites of women who had fewer children were perceived as more attractive (for men evaluators: $t_{(116)} = -32.23$, $p < .001$, Cohen's $d = -2.980$; for women evaluators: $t_{(453)} = -59.23$, $p < .001$, Cohen's $d = -2.780$), more healthy (for men evaluators: $t_{(106)} = -13.58$, $p < .001$, Cohen's $d = -1.312$; for women evaluators: $t_{(428)} = -27.31$, $p < .001$, Cohen's $d = -1.318$) and younger-looking (for men evaluators: $t_{(106)} = -14.32$, $p < .001$, Cohen's $d = -1.384$; for women evaluators: $t_{(430)} = -37.86$, $p < .001$, Cohen's $d = -1.824$) than women with higher parity (Figure 2).

To examine effects of ParCats and sex of a judge, mixed model ANOVA with mean choice was calculated separately for each comparison with the three ParCats (Low vs. Medium, Medium vs. High and Low vs. High) as a within participant factor and sex of participant (male/female) as a between participant factor. For attractiveness judgments, this revealed a significant main effect of ParCats ($F_{(2,\ 1132)} = 639.65$, $p < .001$, $\eta^2 = 0.530$). The interactions between ParCats and sex of a judge ($F_{(2,\ 1132)} = 0.88$, $p = .416$, $\eta^2 = 0.001$) and main effect of sex of a judge ($F_{(1,\ 566)} = 0.04$, $p = .837$, $\eta^2 < 0.001$) were not significant.

A significant main effect of ParCats ($F_{(2,\ 1060)} = 99.44$, $p < .001$, $\eta^2 = 0.158$) was also revealed for health judgments. There were no significant interactions between ParCats and sex of a judge ($F_{(2,\ 1060)} = 0.31$, $p = .732$, $\eta^2 < 0.001$), or main effect of sex of judge ($F_{(1,\ 530)} = 0.03$, $p = .855$, $\eta^2 < 0.001$). Similarly, for perceived age judgments there was a significant main effect of ParCats ($F_{(2,\ 1068)} = 238.40$, $p < .001$, $\eta^2 = 0.308$), but no significant interactions between ParCats and sex of a judge ($F_{(2,\ 1068)} = 0.64$, $p = .528$, $\eta^2 = 0.001$), or main effect of sex of a judge ($F_{(1,\ 534)} = 3.55$, $p = .060$, $\eta^2 = 0.007$). Higher attractiveness, better health and younger look of women's faces with lower number of children were more pronounced for comparisons against the highest category of parity (Low and Medium vs. High; Figure 3).

4 | DISCUSSION

In this study, we tested whether parity is related to facial appearance in post-reproductive age women. We have shown that post-menopausal women who had fewer children were judged as more attractive, younger and healthier than women with more children, by both men and women. In each category, the lowest scores were received by women who had very high parity (7–9 children). In women, reproductive processes require high investment and are associated with many physiological changes (e.g. increased metabolic rate, high levels of oxidative stress, increased systemic inflammation (Butte & King, 2005; Marttila et al., 2015; Ziomkiewicz et al., 2016)). While some of these changes are reversible, others have permanent impact on the organism, as shown by poorer health and increased mortality of women with high parity (Dribe, 2004; Kington, Lillard, & Rogowski, 1997;

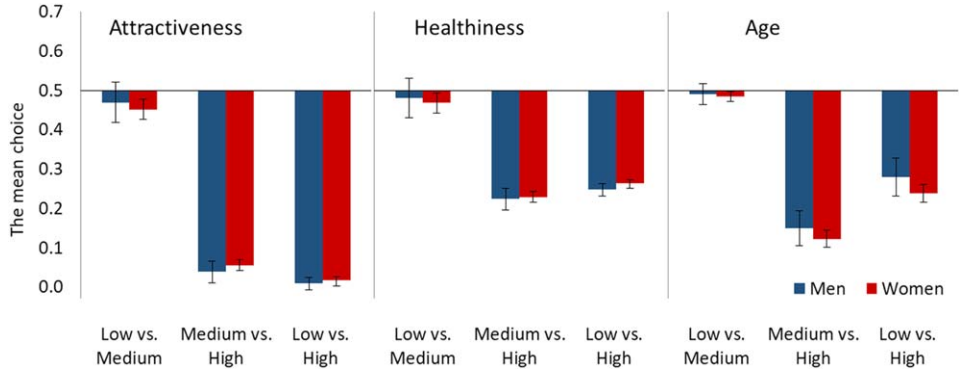

FIGURE 3 Mean choices for each comparison among the three ParCat (Low vs. Medium, Medium vs. High and Low vs. High)

Manor, Eisenbach, Israeli, & Friedlander, 2000). Our results suggest that reproduction also has permanent impact on facial appearance, because faces of women with high parity are perceived as less healthy, older and less attractive. Retrospective studies, based on photographs taken at a young age, have shown that women who had higher lifetime reproductive success had higher attractiveness (Jokela, 2009) and lower levels of facial fluctuating asymmetry (Pflüger, Oberzaucher, Katina, Holzleitner, & Grammer, 2012) at youth. Therefore, we hypothesize, that multiple pregnancies and thus high reproductive costs, might play a crucial role in changing women's facial appearance through the lifespan.

A plausible underlying mechanism comes from a link between offspring number and oxidative stress. Pregnancy and lactation are associated with high energy expenditure due to fetal development and maternal body maintenance (Butte & King, 2005) which, in turn, causes higher levels of oxidative stress (Agarwal, Gupta, & Sharma, 2005). It has been previously shown that women who had more children during their reproductive lifespan had higher level of oxidative stress in postmenopausal age than women with lower parity (Ziomkiewicz et al., 2016). High oxidative stress leads to accelerated aging of the face, especially affecting skin's sagging and pigmentation (Allerhand et al., 2011). This mechanism could explain the results of our study which showed a positive relationship between offspring number and perceived older age, worse health and lower attractiveness of the judged composite facial stimuli, especially in the case of women with high reproductive effort (High Parity Category). Composite images captured both the shape and color cues associated with varying offspring number, so they convey enough information about women's perceived age to be detected by the judges.

It is possible that all three features (perceived age, health and attractiveness) are related to each other and together are govern by a domain-general cognitive tool for recognizing good somatic state of individuals based on his/her face. As faces are of crucial importance in human relations (Perrett, 2012), human brain is equipped with a set of mechanisms dedicated to perceiving information conveyed by faces (Kanwisher & Yovel, 2006), but also associating faces with certain traits (Hassin & Trope, 2000). In this study, judges were, on average, much younger than judged stimuli (post-menopausal women). We hence suggest that the cognitive tool which led them more frequently to choose women of lower parity as younger, healthier and more attractive is independent of apparent age of the person being judged. Sensitivity to somatic condition is clearly important and effective in humans, not only when choosing putative partners.

In summary, our study, based on high quality facial images of women from a high-parity population, using innovative computer graphic techniques to isolate both shape and color cues associated with offspring number, provides new insights into the reproductive costs bear by women and biology of aging. While existence of tradeoffs between reproduction and maintenance is one of the main predictions of life history theory data provided by studies on humans are inconclusive. Our study proposed a different approach to study long-term reproductive costs, i.e. instead of evaluating physiological condition and aging of women, we tested if others are able to detect reproductive costs just by looking at faces of older women. This method could be used in future studies, for example, by creating composite pictures of women that differ in parity, but for whom also data about physiological assessment of reproductive costs (i.e. level of oxidative stress or inflammation) are available. Our results suggest that facial characteristics are a reflection (visible for others) of past reproductive effort and accumulation of lifetime reproductive costs.

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ORCID

Andrzej Galbarczyk http://orcid.org/0000-0002-7879-9735

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