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Paternal age negatively predicts offspring physical attractiveness in two, large, nationally representative datasets

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ABSTRACT

The effect of paternal age on offspring attractiveness has recently been investigated. Negative effects are predicted as paternal age is a strong proxy for the numbers of common *de novo* mutations found in the genomes of offspring. As an indicator of underlying genetic quality or fitness, offspring attractiveness should decrease as paternal age increases, evidencing the fitness-reducing effects of these mutations. Thus far results are mixed, with one study finding the predicted effect, and a second smaller study finding the opposite. Here the effect is investigated using two large and representative datasets (Add Health and NCDS), both of which contain data on physical attractiveness and paternal age. The effect is present in both datasets, even after controlling for maternal age at subject's birth, age of offspring, sex, race, parental and offspring (in the case of Add Health) socio-economic characteristics, parental age at first marriage (in the case of Add Health) and birth order. The apparent robustness of the effect to different operationalizations of attractiveness suggests high generalizability, however the results must be interpreted with caution, as controls for parental levels of attractiveness were indirect only in the present study.

1. Introduction

Paternal age is an extremely strong proxy for the presence of common *de novo* Single Nucleotide Polymorphism mutations in the genomes of offspring. Each additional year of paternal age results in an average of two new mutations being added to the haploid genomes of sperm cells. At age 35, males typically bequeath around 70 new mutations to their offspring (Kong et al., 2012). It is estimated that a little over two of these mutations will have deleterious effects (Keightley, 2012). Establishing relationships between paternal age and offspring traits is therefore potentially highly informative in terms of estimating the sensitivity of those traits to the effects of common and mildly deleterious mutations, which in turn serves as an index of the degree to which the trait may be under mutation-selection balance (e.g. Arslan, Penke, Johnson, Iacono, & McGue, 2014). Paternal age effects also permit predictions from Fitness Indicators Theory to be tested. This theory predicts that pleiotropic mutations create genetic correlations among distinct sources of physical and psychological individual differences causing them to cohere into a latent general Fitness (F) factor (Houle, 2000; Miller, 2000; Penke, Denissen, & Miller, 2007). Phenotypic levels of this latent factor are reflected in *developmental stability*, which relates to the degree to which the effects of genetic and environmental disturbances interfere with the development of a trait (Penke et al., 2007; Waddington, 1942). Traits that are sensitive to mutations will develop optimally in the presence of a low load of deleterious mutations and abnormally in the presence of a high load, thus the levels of such traits can potentially serve as honest phenotypic signals of underlying fitness in sexual selection (Houle, 2000; Miller, 2000; Penke et al., 2007).

Consistent with this model, relationships have been established between paternal age and offspring levels of traits believed to signal neurodevelopmental stability, such as autism (Kong et al., 2012), schizophrenia (Brown et al., 2002) and attention deficit/hyperactivity disorder (D'Onofrio et al., 2014). Offspring general intelligence on the other hand does not appear to be sensitive to paternal age, contrary to predictions from Fitness Indicators Theory (Arslan et al., 2014; D'Onofrio et al., 2014).

One phenotypic trait that is expected to be highly sensitive to deleterious mutations is physical attractiveness. Attractiveness is believed to relate in part to the property of *symmetry* (Grammer & Thornhill, 1994), which is a highly general indicator of developmental stability (van Valen, 1962). Thus far, two studies have investigated the association between paternal age and physical attractiveness yielding mixed results. Huber and Fieder (2014) utilized a large mixed-sex sample ($n = 10{,}317$) drawn from the Wisconsin Longitudinal Study (WLS) for

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which data on facial attractiveness (evaluated using multiple, convergent ratings of attractiveness based on high school photographs) and both paternal and maternal age at birth were available. The bivariate correlation between facial attractiveness and paternal age was found to be −0.071, and the correlation with maternal age was found to be −0.029 (both were statistically significant). General Linear Models were constructed to evaluate the effect of controlling for various confounds, including subject's birth year, sex, father's age at birth of subject's eldest sibling and time to subject's birth (the last two control for the potential confounding effects of paternal attractiveness on the basis that less attractive males may take longer to find mates and produce offspring). Two separate models were run, one in which maternal age at subject's birth was controlled, and a second model in which the paternal physical attractiveness proxies were used as controls instead of maternal age. Both models yielded significant, negative effects of paternal age on offspring facial attractiveness ($b = -0.021$ in the case of Model 1, and −0.011 in the case of Model 2), consistent with the theory that advanced paternal age should reduce offspring attractiveness. Model 1 also found an independent significant *positive* effect of advanced maternal age on offspring attractiveness ($b = 0.013$), however additional analysis (involving different model specifications) indicated an inconsistent effect.

The only other study to investigate this question was that of Lee et al. (2016). This study utilized a relatively smaller mixed-sex sample ($n = 1823$) of monozygotic and dizygotic twins and their siblings to investigate the genetic architecture of the correlation between facial attractiveness (evaluated using convergent ratings of attractiveness) and facial averageness (evaluated using computer aided geometric morphometric analysis). Multiple regression analysis was used to determine whether there was any effect of paternal and maternal age on both facial attractiveness and facial averageness, after controlling for sex, the year in which the photograph was taken and subject's age. Neither paternal nor maternal age exhibited a significant effect on facial averageness ($\beta = -0.03$ and −0.01 respectively), however a significant *positive* effect of paternal age on facial attractiveness was found ($\beta = 0.09$), which runs contrary to Huber and Fieder's (2014) finding.

In the present study, we will revisit the question of whether or not there is a paternal age effect on offspring physical attractiveness utilizing two, large and representative, datasets (Add Health and the National Child Development Study) that are sourced from two different countries (the US and UK respectively). These datasets contain data on physical attractiveness and paternal age, along with a variety of covariates.

2. Methods and data

2.1. Add Health

The National Longitudinal Study of Adolescent Health (Add Health) is a large, nationally representative, and prospectively longitudinal study of young Americans. A sample of 20,745 adolescents were personally interviewed in their homes between 1994 and 1995 (Wave I; mean age = 15.6). They were again interviewed in 1996 (Wave II; $n = 14{,}738$; mean age = 16.2), in 2001–2002 (Wave III; $n = 15{,}197$; mean age = 22.0), and in 2007–2008 (Wave IV; $n = 15{,}701$; mean age = 29.1). Additional details of sampling and study design are provided at: http://www.cpc.unc.edu/projects/addhealth/design.

2.1.1. Dependent variable: physical attractiveness

At the conclusion of the in-home interview at each wave, the Add Health interviewer rated the respondent's physical attractiveness on a five-point ordinal scale (1 = very unattractive, 2 = unattractive, 3 = about average, 4 = attractive, 5 = very attractive). We performed a factor analysis with the four attractiveness scores given by four different interviewers at four different times spanning 12 years, yielding a *longitudinal* physical attractiveness measure. To compute the factor score, a Unit-Weighted Factor analysis was performed in which each participant's attractiveness ratings for each time-point were standardized – the average of the ratings across all four time-points yielded the unit-weighted longitudinal composite physical attractiveness measure for the participants. By specifying the common factor *a priori*, unit-weighting the indicators avoids the well-documented sample and indicator-specificity of factor scoring coefficients produced by standard errors of inconsistent magnitudes across different samples, and is considered to be the only method suitable for isolating common factor variance when either indicator of case numbers are low, as in the present study (Gorsuch, 1983). The loadings of each indicator onto the unit-weighted common factor can be computed by simply correlating each indicator with the common factor score (Gorsuch, 1983). Doing so reveals high-magnitude loadings of the unit-weighted longitudinal attractiveness score onto each of its component indicators (Wave $I = 0.646$, Wave II = 0.661, Wave III = 0.611, Wave IV = 0.581). We used the unit-weighted factor, with a mean of 0 and a standard deviation of 1, as the dependent variable in an Ordinary Least Squares (OLS) regression (implemented in SPSS v.22.0.0.2).

2.1.2. Independent variables

Our main independent variable was father's age at respondent's birth measured at Wave 1. Potential confounds that were controlled included mother's age at the respondent's birth (in order to control for potentially independent effects of maternal age on offspring attractiveness), the respondent's birth year (in order to control for potential secular trends in physical attractiveness, as noted by Huber & Fieder, 2014) and the respondent's sex (0 = female, 1 = male; in order to control for potential dimorphic effects on ratings of subject attractiveness). The respondent's race was measured with three dummy variables for Black, Asian and Native American (with White as the reference category) in order to control for the effects of race on perceived attractiveness (e.g. Lewis, 2011). Parent's income and respondent's earnings were included in the model (these were transformed using a natural logarithm in order to compensate for skewness) to control for the potential effects of socio-economic status on offspring attractiveness, on the premise that low socio-economic status may reduce the condition of the offspring or influence their perceived attractiveness. Parental socioeconomic characteristics furthermore serve as indirect controls for parental attractiveness, as robust positive associations have been observed between attractiveness and earnings (e.g. Hamermesh & Biddle, 1994; Scholz & Sicinski, 2015). Parental age at first marriage was also included as an indirect control for parental attractiveness on the basis that less attractive parents may take longer to find mates (in the same vein as Huber and Fieder's use of father's age at birth of subject's eldest sibling and time to subject's birth). Finally subject's birth order was included as a covariate on the basis that there may be within-family influences on physical attractiveness, perhaps via maternal immunoreactivity or post-natal discriminative parental solicitude with respect to earlier-born offspring (e.g. Zajonc & Sulloway, 2007). Consistent with this possibility, there are indications of birth-order effects on one component of attractiveness, i.e. symmetry (Lalumière, Harris, & Rice, 1999). The latter control is especially important as, if it can be shown that the effect is due to *between* rather than purely *within* family influences, it strengthens the case for it being mutagenic in origin, especially when considered in the context of the other covariates (e.g. Arslan et al., 2014; D'Onofrio et al., 2014). The covariates were also measured at Wave I.

2.2. NCDS

The National Child Development Study (NCDS) is an on-going large-scale prospectively longitudinal study, which has followed a *population* of British respondents since birth for more than half a century. The study included *all* babies ($n = 17{,}419$) born in Great Britain (England, Wales, and Scotland) during one week (03–09 March 1958). The respondents were subsequently reinterviewed in 1965 (Sweep 1 at age 7; $n =$

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