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Biology and being green: The effect of prenatal testosterone exposure on pro-environmental consumption behaviour

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Abstract

The gap between men and women in terms of pro-environmental behaviour has been attributed in prior research to differences in personality traits and to perceived threats to gender identity; pro-environmental behaviours are stereotypically viewed as more feminine than masculine. This paper explores the effect of another source of gender-related attitude and behaviour differences: pre-natal exposure to testosterone and oestrogen. To do so, an established biomarker, the ratio of the length of the second and fourth digits of the hand (the 2D:4D ratio), is employed. A nonlinear (U-shaped) relationship between pro-environmental behaviour and 2D:4D ratio is found for males only, suggesting that greater engagement with pro-environmental behaviour is associated not only with more feminine digit ratios, but also with more masculine ratios. This would suggest that two separate underlying mechanisms linking pro-environmental behaviour and pre-natal androgen exposure are at work.

Forthcoming in the *Journal of Business Research*

1. Introduction

Making changes to consumption behaviours and practices is the most accessible way for individuals and households to contribute to sustainable development and to environmental protection (Moser, 2015). As Steg and Vlek (2009) note, changes in purchase behaviour offer greater potential environmental benefit than re-using or recycling, as does reducing consumption of energy (e.g. by lowering the thermostat setting or reducing car use). However, there is some evidence that, compared to women, men are less likely to engage in pro-environmental consumption behaviours (e.g. Davidson and Freudenberg, 1996; Brough, Wilkie, Ma, Isaac and Gal, 2016).

The antecedents of pro-environmental attitudes and behaviour have long received attention in the psychology literature (e.g. Hines, Hungerford and Tomera, 1986/7; Bamberg and Möser, 2007) and increasingly so in the consumer research literature (e.g. Moser, 2015; Brough, Wilkie, Ma, Isaac and Gal, 2016). From this, a number of predictors have been suggested for pro-environmental behaviour, with the most consistent findings being that environmental supporters tend to be younger, better educated and politically moderate. Gender has also been found to have a significant effect with women being more likely to adopt pro-environmental behaviour than men are (e.g. Davidson and Freudenberg, 1996; Zelezny, Chu and Aldrich, 2000; Hunter, Hatch and Johnson, 2004). Findings regarding the effect of variables such as income, urban versus rural location and religiosity are less consistent, although as Klineberg et al. (1998) show this might be a result of different studies using different measures of environmental concern.

There is increasing evidence that consumers' choices and behaviours are also influenced by hormone levels. Recent studies have explored the effect on circulating hormone levels on consumers' choices and preferences (e.g. Durante, Griskevicius, Hill, Perilloux and Li, 2011; Doi, Basadonne, Venuti and Shinohara, 2018). However, pre-natal hormone exposure can also have a long-lasting impact on attitudes and behaviour (e.g. Archer, 2006; Auyeng, Baron-Cohen, Ashwin, Knickmeyer, Taylor, Hackett et al., 2009). Findings in the psychology and biomedical literature suggest that gender differences in attitudes and behaviours are influenced by pre-natal exposure to sex hormones (such as testosterone and oestrogen). The aim of this paper is to explore if such pre-natal exposure can explain the differences between men and women in pro-environmental attitudes and behaviour, building on recent findings suggesting that pro-environmentalism is seem as more feminine than masculine (e.g. Brough *et al.*, 2016) . To do so, a biomarker of pre-natal androgen exposure, the ratio of the lengths of the second and fourth fingers, is employed. As such it in part answers the call by Nepomuceno, Saad, Stenstrom, Mendenhall and Iglesias (2016a) for future digit ratio research to "consider investigating dependent variables that are relevant to the feminizing effects of estrogen" (p.241).

2. Conceptual development

2.1 Environmental Concerns

Research on gender and environmental concern reveals that women tend to display greater levels of environmental concern than men (Davidson and Freudenburg, 1996; Zelezny, Chua and Aldrich, 2000; Hunter, Hatch and Johnson, 2004). Although a number of possible hypotheses have been suggested to account for this difference only one, the safety concerns hypotheses, has received consistent support (Davidson and Freudenburg, 1996). The safety concerns hypotheses involves two propositions: 1) that health and safety are more salient to women than to men and 2) this greater salience is reflected in higher levels of concern about a given level of environmental risk. In their review of the literature, Davidson and Freudenburg (1996) found no study which reports evidence against the safety concerns hypothesis and 16 studies presenting evidence to support it. Hunter, Hatch and Johnson

(2004) present evidence that the gender difference finding largely holds across 22 nations and holds when a distinction is drawn between public and private pro-environmental behaviours. Private behaviours are defined as those such as recycling which are largely hidden from public view whilst public behaviours include things like participating in environmental protests. Their results suggest that private behaviours are more common than public behaviours, but the hypothesis than men would be more likely than women to engage in public behaviours was not supported. A greater gender difference is seen in countries with higher national incomes than lower, with private pro-environmental behaviours becoming more feminized.

These findings have been characterized as reflecting stereotypical expectations of genders, with women being associated with taking the roles of carer and nurturer. Similar findings apply when consumption is investigated: green consumers are rated as more co-operative, altruistic and ethical than non-green consumers (e.g. Mazar and Zhong, 2010). As men tend to be more concerned with maintaining gender-identity (e.g. Bosson and Michniewicz, 2013), such stereotypically feminine associations may act as a barrier to adopting pro-environmental behaviour. Using a range of experiments and indirect measures, Brough et al. (2016) find evidence that greenness and femininity are cognitively linked in US samples. In one experiment respondents associated stereotypical female traits more with both men and women using a re-usable canvas shopping bag (green behaviour) rather than with people using plastic bags for groceries. Conversely, they show that pro-environmental behaviour (amongst men) can be encouraged through the use of more masculine imagery and branding.

Such perceptions of pro-environmental behaviour as more feminine than masculine could, however, be supplanted by other social norms. For example, Rettie, Burchill and Barnham (2014) suggest that portraying pro-environmental activities as normal and everyday activities, rather than being "green", would encourage their adoption more effectively. Such positioning of pro-environmental behaviour would reduce the perceived threat to gender identity. A norms based approach could also be used to trigger competitive behaviour. Harries, Rettie, Studley, Burchell and Chambers (2013) show that energy consumption is reduced when feedback on usage is given, although they found the reduction was no greater when social comparison information was included alongside household information. This suggests that positioning usage level as a target is on its own enough to engage a degree of competitiveness (either competing against own past performance or against other people or households). van Horen, van der Wal and Grinstein (2018) also find that competition promotes sustainable behaviour. Furthermore, when competition is used as a means to an end it does not seem to alienate people with pro-social motivations for sustainable behaviour. Pro-environmental or green consumption, as it often involves a higher cost than consuming non-green alternatives, can be seen as a form of conspicuous consumption. For example, Griskevicius, Tybur and Van den Bergh (2010) find that status motives lead to greater choice of green products over non-green products when the choice was public and the green good cost more. From this, they conclude that status competition could be used to promote green behaviour.

2.2 Pre-natal hormone exposure, the Digit Ratio and behaviour

In addition to being influenced by societal norms and stereotypes, there is evidence in the psychology and biomedical literature that gender-related behaviours are also affected by exposure to sex hormones during pre-natal development (e.g. Cohen-Bendahan, van de Beek and Berenbaum, 2005). Relative exposure to pre-natal testosterone and oestrogen is reflected in the ratio of the lengths of the second (index) and fourth (ring) fingers (abbreviated as 2D:4D. Specifically, testosterone appears to stimulate growth of the fourth digit whilst exposure to estrogen promotes growth of the second digit (Manning, 2002). Consequently, a low 2D:4D ratio is associated with higher levels of fetal testosterone and lower levels of fetal estrogen, whilst a high 2D:4D ratio suggests exposure to lower levels of testosterone and higher levels of estrogen (e.g. Manning, Kilduff, Cook, Crewther and Fink, 2014; however, for a dissenting view see Berenbaum, Bryk, Nowak, Quigley and Moffat, 2009). Once established, the ratio remains stable over time (Trivers, Manning and Jacobson, 2006). It is also sexually dimorphic, with males displaying on average relatively longer ring fingers than index fingers and a lower ratio for the right hand (R2D:4D) than the left hand (L2D:4D). The difference between the two ratios also reflects effect of prenatal androgens (like testosterone) and so is sometimes used as an additional variable (Manning, 2002).

The effect of the digit ratio on a wide range of psychological constructs has been explored. It has for example been shown to relate to aspects of personality; Austin, Manning, McInroy and Mathews (2002) found significant positive correlation between left hand digit ratios and neuroticism and a significant negative correlation with psychoticism (when split by sex the correlations coefficients remained of a similar size, but were not statistically significant) whilst Fink, Manning and Neave (2004) found a significant positive correlation between the right hand digit ratio and neuroticism and a negative correlation with agreeableness, but only for females. Richards, Stewart-Williams and Reed (2015) found a significant positive between the right hand digit ration and locus of control for females, but not for males. There is some evidence for a relationship between the digit ratio and altruism. Brañas-Garza, Kovárík and Neyse (2013) report and inverted u-shaped relationship for both left and right hand digit ratios, although the patterns is more consistent for males; Galizzi and Nieboer (2015) replicate this finding from a multi-ethic sample. The digit ratio has also been associated with competitiveness. Bönte, Procher, Urbig and Voracek (2017) find a robust and significant negative relationship between the digit ratio and self-reported competitiveness, but no relationship with competitiveness in economic experiments.

The more recent evidence however seems to suggest a weaker or non-existent relationship between the digit ratio and socio-economic decision-making. The suggested relationship between digit ratios and sensation-seeking (e.g. Fink, Neave, Laughton and Manning, 2006) has not been replicated (e.g. Voracek, Tran and Dressler, 2010), whilst Alonso, Di Paolo, Ponti and Satrarelli (2018) find the effect of the digit ratio on social preferences is moderated by cognitive ability and no effect on risky choices. Overviews of research in the area are given by Manning (2002), Voracek and Loibl (2009) and Hines (2010).

The majority of studies have tested for a linear relationship between the digit ratio and the dependent variable. However, there is some evidence that suggests the relationship between digit ratio and altruism is nonlinear rather than linear (e.g. Brañas-Garza, Kovářík and Neyse, 2013; Galizzi and Nieboer, 2015). Assuming that the relationship between the digit ratio and a dependent variable is linear involves making the assumption that the effect of an increase in exposure to testosterone (reducing the digit ratio below one) has the same direction and magnitude of effect as increase in exposure to estrogen (increasing the digit ratio above one).

The effect of the digit ratio has been less explored in Business research. The association between digit ratio and entrepreneurship has received some attention (e.g. Bönte, Procher and Urbig, 2015) but its association with consumer behaviour is underexplored. Based on two studies, Aspara and Van Den Bergh (2014) they show that a lower digit ratio (i.e. a longer ring finger than index finger) significantly predicted choice of products with a more masculine image. In the first study, the digit ratio predicted choice of Coca-Cola brands where, based on a pre-test, Regular Coke was regarded as having a more masculine image, Diet Coke more feminine and Coke Zero having a neutral image. Amongst men a lower digit ratio was associated with choosing regular Coke, but no significant association was found among women. They also found an association between the digit ratio and choice of clothing colours, with colours identified in a pre-test as being used more by men being associated with a lower digit ratio. Similarly, a higher digit ratio among men has been found to be related to status-signalling consumption. Otterbring, Ringler, Siriani and Gustafsson, (2018) found that among men, a higher digit ratio increased the effect of exposure to a physically dominant male model on intrasexual competition, which in turn increased preference for status signalling goods.

Digit ratios have also been found to relate to courtship related consumption (Nepomuceno, et al. 2016a) and to erotic gift-giving (Nepomuceno, Saad, Stenstrom, Mendenhall and Iglesias, 2016b). Amongst men, a more masculine digit ratio is associated with greater courtship related consumption, both to acquire and retain a mate. Amongst women, a more feminine digit ratio was found to be related to greater courtship related consumption (Nepomuceno et al 2016a). Nepomuceno et al (2106b) find a relationship between a masculine digit ratio and erotic gift-giving, but only among men with high mating confidence.

A number of conclusions can be drawn from the literature discussed above. First, that men tend to engage less with pro-environmental activities. Second, that such activities are subconsciously regarded as more feminine than masculine (e.g. Brough et al, 2016). However, such perceptions could be overridden by social norms (for example using re-usable shopping bags after the introduction of charges for single-use plastic grocery bags as in the UK) or by pro-environmental activities being undertaken as status-seeking behaviour (e.g. Harries et al, 2016; Griskevicius et al, 2010). Third, greater pre-natal exposure to testosterone is associated with greater preference for more "masculine" products and behaviours.

From this, two competing expectations can be drawn. First, that a lower (more masculine) digit ratio will be associated with lesser engagement in pro-environmental activities; in other words the eco-friendly is unmanly effect dominates. Conversely, a higher (more "feminine") digit ratio will be associated with greater engagement in pro-environmental activities. Second, if displays of eco-friendly behaviour support or enhance social status, then a more "masculine" digit ratio, if associated with greater competitiveness, should be associated with greater (not lesser) engagement in pro-environmental activities. It is possible that these two mechanisms both operate; they need not be mutually exclusive. This would imply a non-linear (potentially u-shaped) relationship, with pro-environmental behaviour being associated with both highly masculine and highly feminine digit ratios. Consequently, this paper tests for both a linear and a non-linear relationship between pro-environmental behaviour and the digit ratio. This relationship is tested for amongst men and women separately to accommodate both differences in the level of environmentally friendly behaviour (with women expected on average to be more environmentally friendly) and differences in the effect of pre-natal exposure to testosterone and oestrogen on behaviour.

3. Methods and Data

The data for this study comes from Wave F of the Innovation Panel of the UK Household Longitudinal Survey, also known as the *Understanding Society* survey (University of Essex. Institute for Social and Economic Research and Kantar Public 2008-2016). Jäckle, Gaia, Al Baghal, Burton and Lynn (2017) provide an overview of the survey. The Innovation Panel runs alongside the *Understanding Society* survey using a separate, smaller sample of 2,149 people in 1,191 households from drawn from across the UK. The sample for the *Innovation Panel* was recruited via a stratified and geographically clustered sampling design, based on post-code sectors in the UK. All members of participating households were interviewed.

Pro-environmental behaviour is measured via a list of 11 behaviours, adapted by the *Understanding Society* survey from those used in surveys by the UK Government's Department for Environment, Food and Rural Affairs (DEFRA, 2008). The list contains nine pro-environmental behaviours and two behaviours which waste resources – the items are shown in table 1. All of the behaviours relate directly or indirectly to changes of consumption behaviour (such as switching to alternatives, reducing usage or postponing purchase).

Table 1 here

Respondents indicate how often they engage in each behaviour on a 1-5 ordinal scale where 1 = always and 5 = never, with a not applicable / does not apply to me option. Responses to the environmentally friendly behaviour items were recoded so a higher number denotes that the activity described is taken more often. The original coding for the environmentally unfriendly items was retained so a high value denotes never undertaking that activity. A score was derived for each respondent by summing their responses and dividing by the number of responses given (so if two of the 11 responses were "does not apply to me", answers to the remaining nine were summed and divided by nine). This gives an index of environmental behaviour; the higher the value the greater the engagement with pro-environmental behaviour. The values in this index are referred to as the environmental score.

Rather than measure pro-environmental behaviour as a reflective latent variable, it is treated more as a formative construct (for discussions of formative versus reflective measures see e.g. Diamantopoulos, Riefler and Roth, 2008; Coltman, Devinney, Midgley and Venaik, 2008) . It need not follow that if a respondent scores high one question he or she would score higher on the others (as would be the case in a traditional reflective latent variable). Rather, respondents might engage in some pro-environmental activities but not others, or may engage in them with different frequencies. In a formative construct, the observed variables related to it should display little collinearity (e.g. Nunally and Bernstein, 1994) – the maximum Variance Inflation Factor for the environmental behaviour questions is 1.11. Confirmatory tetrad analysis (Bollen and Ting, 1993; Gudergan, Ringle, Wende and Will, 2008) provides a way of testing if a reflective conceptualisation can be supported. The results, shown in table A1 in the appendix, support treating the variable as formative, with the null hypothesis that the construct is reflective being rejected. As Diamantopoulos *et al.* (2008) note, this can also be interpreted as a test of the construct's validity.

Turning attention to the focal explanatory variable, the survey contains two types of finger length measurements: measurements taken by interviewers using Vernier callipers and respondent self-reported measures. Self-reported measures of finger length are more prone to extreme values and greater random measurement error and tend to be higher compared to measures taken from photocopies / scans of hands (Caswell and Manning, 2009). Similarly, directly measured finger lengths tend to be greater than indirect measures from scans or photocopies; such systematic biases in measurement form an important issue for digit ratio research and are reviewed by Ribeiro, Neave, Morais and Manning (2016). The source of these differences is not yet understood. The issue is complicated by a lack of clarity in how results are reported, with some evidence of lab-specific differences between measurements, causing much concern in the 2D:4D literature (e.g. Fink and Manning, 2018).

To reduce the potential for measurement error, only interviewer derived measures are used. This ensures consistency in measurement device and in the process of measurement. It also provides consistency in measurement units; some self-report measures are given in inches and sixteenths of an inch as opposed to millimetres. Finger length measures were taken by *Understanding Society* interviewers as part of the data collection for the *Innovation Panel wave 6*. Interviewers following the same protocol took finger measures using digital Vernier callipers that were calibrated before each measurement. The measures were taken directly from each respondent (not from photocopies or scans). Respondents were asked to lay their hands flat with palms upwards. The callipers were then placed with the fixed jaw at the middle of the bottom crease of the finger to be measured and the movable jaw moved to the tip of the finger. Finger length measurements were taken in order: right index finger, right ring finger, left index finger and left ring finger (for details of the measurement protocol, see NatCen, no date). The use of directly measured finger lengths (as opposed to indirect from scans or photocopies) is a strength of the approach adopted here. However, a limitation is that each finger was only measured once. A reliability check is therefore not possible.

Digit ratios can vary considerably across ethic groups (e.g. Manning and Fink, 2008). The sample for this study is predominantly white British (90.2%) with a further 2.6% being of any other white background. No other ethnic group accounts for more than 1.6% of the sample.

Variables capturing demographic characteristics which have been consistently associated with pro-environmental behaviour were also derived from the survey. The respondent's sex, age measured in years, education level (whether the respondent held a Higher Education / University qualification) and reported household income were extracted from the survey.

4. Results

4.1 Descriptive Statistics

Although the Innovation Panel contains 2,149 respondents, interviewer-measured digit lengths were only collected from 1,090 adults (487 male and 603 female). Digit ratios are known to vary across ethnic groups (e.g. Manning, 2008). To avoid any confounding effects of ethnicity, the sample is restricted to the largest ethnic group in *Understanding Society* data set (white British), which accounts for approximately 80% of the responses. This reduces the sample size to 889 (400 male and 489 female). When this reduced sample is used the digit ratio data contains a number of extreme values as shown in table 2 (the largest ratio is 3.19 and the smallest 0.33). To address this, observations below the 1st and above the 99th percentiles were omitted as outliers. Table 2 also gives descriptive statistics for the dependent variable and other explanatory variables.

Table 2 here

The digit ratio is sexually dimorphic, with men tending to have lower ratios than women. This pattern is also found here, as shown in table 2. However, the difference between the sexes is rather smaller than expected. The differences in the right hand trimmed digit ratio are significant at the 10% level (t = -1.405, df = 887, sig = 0.08 one-tailed, Cohen's d = 0.09), whilst the difference in the left hand ratio is significant (t = -3.643, df = 884, sig = 0.0001 one-tailed, Cohen's d = 0.245). The standard deviations for the digit ratios are somewhat higher than would be expected. Consequently, the results below should be evaluated with a slight caveat regarding the noise in the digit ratio measures.

Table 2 also shows that women have a slightly higher environmental score than men ($mean_{men}$ = 2.83 and $mean_{women}$ = 2.91, (t = 1.895, df = 884, sig = 0.0254, Cohen's d = 0.127). Although the difference between the two means is statistically significant, the effect size lies below the conventional benchmark for a small effect. This might suggest that the findings in the literature from the US do not fully translate to the UK (perhaps reflecting the effect of efforts to promote energy efficiency and recycling in recent years).

4.2 Regression and two line test results

Table 3 contains OLS regression results for men and women separately with the digit ratio included as a predictor of the environmental score, along with demographic controls. Table 4 shows regression results when the square of the digit ratio is introduced to the model.

Table 3 here

Table 4 here

As table 3 shows, the left hand and right hand digit ratios are not significant for men nor are they significant for women. However, when the squared digit ratio is introduced (table 4), both it and the digit ratio are significant for men in both the right hand and the left hand). For women, both terms are non-significant. The data comes from a household survey, so as a robustness check the significance tests were recalculated using standard errors clustered by household; no substantive differences were observed.

The regression results imply a curvilinear relationship for males. There are however, some concerns about using quadratic terms to test specifically for a u-shaped relationship (as opposed to testing for nonlinear effects). Quadratic terms can produce both false positive and false negative results; an alternative approach, known as the two lines test, tests if the effect of variable x on variable y changes sign for higher values of x versus lower values of x, with the breakpoint decided by an algorithm (Simonsohn, 2018). As a double check of the results, the two lines test was applied to the right hand and left hand digit ratios for both the male and female samples (using the version provided at http://webstimate.org/twolines). The estimated slope coefficients and significance test results are shown in table 5.

Table 5 here

For the male sample, both right and left hand digit ratios show significant negative coefficients for lower values of the digit ratio (average slope 1), with a non-significant coefficient for higher levels of the digit ratio (average slope 2). This would suggest a non-linear relationship, but not a u-shaped one, as shown in figures 1 and 2 (in the figures, “RDR” and “LDR” denote right hand digit ratio and left hand digit ratio respectively whilst “ENV” denotes the environmental score). For females neither the left hand nor the right hand results are significant.

Figures 1 & 2 here

The results suggest a nonlinear relationship between the digit ratio and environmental behaviour for men, but not in the form that was expected. A higher, more feminine digit ratio in men is not associated with greater pro-environmental behaviour. This seems to contradict the notion of eco-friendly behaviour being “unmanly”. Rather, as both the regression results and (more clearly) the two lines test results imply that amongst men a lower (more masculine) digit ratio is associated with greater pro-environmental behaviour. This could imply that men with a more “masculine” digit ratio do not perceive pro-environmental behaviour to threaten their gender identity compared to men with a less masculine digit ratio. Secondly, a more masculine digit ratio could be associated greater sense of competition or of status-seeking which then manifests itself in greater (reported) pro-environmental activity.

5. Conclusions

The results presented here suggest that there is a relationship between pro-environmental behaviour and pre-natal sex hormone exposure in males, but not in females. Furthermore, that relationship is rather more complex than expected and does not accord with the eco-friendly is unmanly stereotype. This may in part reflect differences in attitudes in the UK, where the data for this study was collected, compared to those found in prior studies which have largely used US data. Consequently, the results have implications for how pro-environmental behaviour might be further encouraged amongst males; amongst females the digit ratio does not appear to be associated with pro-environmental behaviour. Using the digit ratio as a base for segmentation would be impractical. However, promotional messages appealing to competitive motives or status-seeking motives might be more successful than those which appeal only to more altruistic or social motives. Future research might explore motivations amongst males for adopting pro-environmental behaviours further, to see if the suggested reasons for the non-linear relationship reported here are supported. In particular, it would be interesting to see if pro-environmental behaviour amongst men with a low digit ratio is driven by competitiveness (and if it is, competition with who) or by status-signalling. The link between pro-environmental behaviour and perceived threats to gender identity could also be explored further, in light of the results presented here.

Like all studies, this one has some limitations. A note of caution also needs to be sounded over the digit ratio measures; these were provided without reliability measures (either intra-observer or repeated measures). The digit ratio measures were collected as part of a larger survey (the *Understanding Society Innovation Panel*) which may have limited the time able to be spent on each element of the study. The measure of pro-environmental behaviour used in this study was determined by the design of the *Understanding Society* survey. Whilst the items used are widely employed in UK Government sponsored surveys, it would be interesting to see if the results can be replicated using other measures of pro-environmental attitudes and behaviour such as the Pro-Environmental Behaviour Scale (Markle, 2013) or the New Ecological Paradigm scale (Dunlap, Van Liere, Mertig and Jones, 2000). Similarly, it would be interesting to see if the digit ratio can predict actual behaviour, rather than respondent self-reports of behaviour. A second avenue for future research is to incorporate personality type alongside the digit ratio as a predictor. The effect of personality type on pro-environmental concern is well-established, with higher scores on openness to experience and agreeableness being positively associated with pro-environmental concerns, as are neuroticism and conscientiousness (e.g. Hirsh and Dolderman, 2007; Hirsh, 2010, Markowitz, Goldberg, Ashton and Lee, 2012). There is also some evidence that personality type is associated with digit ratio, particularly in females (e.g. Fink, Manning and Neave, 2004). How these personality effects interact with the digit ratio effects identified here would also be an interesting avenue for future research.

The results presented here provide further evidence of the usefulness of the digit ratio biomarker of pre-natal sex hormone exposure as a predictor of consumer choice and behaviour. As such the results contribute to the growing literature on hormonal (e.g. Durante et al., 2011) and more broadly biological and evolutionary influences on consumers' actions and decisions (e.g. Saad, 2007; Griskevicius and Kenrick, 2013).

Acknowledgement

I am grateful to the four anonymous *JBR* reviewers and the special issue editors for their challenging and constructive comments and suggestions which have improved the paper.

Funding Statement

This research did not receive any specific from funding agencies in the public, commercial or not-for-profit sectors

Appendix

Table A1 here

Any significant result (where the confidence interval does not include 0, highlighted in bold in table A1) suggests that the construct cannot be treated as reflective. A tetrad is the difference of the products of two sets of indicator covariances. All such model implied tetrads will be zero if the measurement model is reflective (Bollen and Ting, 2000). The table shows the results of a test of whether each tetrad is significantly different to zero, along with Bonferroni adjusted confidence intervals.

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Table 1. Environmental Habits

Environmentally friendly behaviours	
Switch off lights in rooms that aren't being used	Use public transport (e.g. bus, train) rather than travel by car
Take your own shopping bag when shopping	Walk or cycle for short journeys less than 2 or 3 miles
Put more clothes on when you feel cold rather than putting the heating on or turning it up	Car share with others who need to make a similar journey

Decide not to buy something because you feel it has too much packaging	Take fewer flights when possible
Buy recycled paper products such as toilet paper or tissues	
Environmentally harmful behaviours	
Leave your TV on standby for the night	Keep the tap running while you brush your teeth

Table 2. Descriptive Statistics

	Mean		Standard Deviation		Minimum		Maximum	
	Male	Female	Male	Female	Male	Female	Male	Female
Dependent variable								
Environmental score	2.831	2.911	0.626	0.644	1.273	1.273	4.857	5.000
Digit ratio variables								

Right hand digit ratio	0.9977	1.001	0.065	0.171	0.711	0.330	1.57	3.190
Left hand digit ratio	0.999	1.010	0.101	0.091	0.813	0.573	2.750	2.368
Trimmed right hand digit ratio	0.996	1.001	0.052	0.062	0.861	0.800	1.231	1.328
Trimmed left hand digit ratio	0.995	1.007	0.046	0.054	0.890	0.862	1.158	1.216
Trimmed right hand digit ratio squared	0.994	1.005	0.105	0.129	0.741	0.640	1.515	1.765
Trimmed left hand digit ratio squared	0.991	1.017	0.093	0.110	0.793	0.742	1.341	1.477
Other independent variables								
Age	50.1	52.47	19.0	18.9	16	16	92	95
Higher education qualification	0.339	0.312	-	-	0	0	1	1
log of household income	10.48	10.37	0.68	0.67	8.38	7.54	12.39	12.39

Note: Higher education qualification is a dummy variable.

Table 3. Digit ratio regression results

	Males					
	Right Hand			Left Hand		
	B	Beta	Sig	B	Beta	Sig
Constant	4.721	-	0.000	4.236	-	0.000
digit ratio	-0.755	-0.063	0.207	-0.200	-0.015	0.766
age	0.003	0.082	0.103	0.003	0.079	0.119

HE qualification	0.119	0.090	0.081	0.129	0.098	0.056
log of household income	-0.126	-0.137	0.008	-0.133	-0.145	0.006
R^2	0.035			0.035		
F test	F(4,398) = 3.552 (p = 0.007)			F(4, 395) = 3.455 (p=0.009)		
Females						
	Right Hand			Left Hand		
	B	Beta	Sig	B	Beta	Sig
Constant	4.027	-	0.000	4.678	-	0.000
digit ratio	0.089	0.009	0.839	-0.457	-0.038	0.387
age	0.006	0.169	0.001	0.005	0.160	0.001
HE qualification	0.147	0.107	0.018	0.128	0.092	0.043
log of household income	-0.150	-0.157	0.001	-0.158	-0.164	0.001
R^2	0.071			0.072		
F test	F(4,486) = 3.535 p<(0.001)			F(4,486) = 9.323 (p<0.001)		

Table 4. Digit ratio and Digit ratio squared regression results

Males						
	Right Hand			Left Hand		
	B	Beta	Sig	B	Beta	Sig
Constant	22.764	-	0.000	25.242	-	0.010
digit ratio	-36.819	-3.053	0.004	-42.076	-3.106	0.032

digit ratio^2	17.893	2.993	0.004	20.838	3.093	0.032
age	0.002	0.066	0.191	0.002	0.067	0.186
HE qualification	0.123	0.092	0.069	0.131	0.100	0.050
log of household income	-0.116	-0.126	0.015	-0.132	-0.144	0.006
R^2	0.054			0.045		
F test	F(5,398) = 4.592 (p<0.001)			F(5, 395) = 3.712 (p=0.003)		
Females						
	Right Hand			Left Hand		
	B	Beta	Sig	B	Beta	Sig
Constant	4.641	-	0.086	4.631	-	0.431
digit ratio	-1.150	-0.115	0.828	-0.366	-0.031	0.974
digit ratio^2	0.620	0.125	0.814	-0.044	-0.008	0.994
age	0.006	0.169	0.001	0.005	0.160	0.001
HE qualification	0.147	0.107	0.019	0.128	0.092	0.044
log of household income	-0.150	-0.156	0.001	-0.158	-0.164	0.001
R^2	0.071			0.072		
F test	F(5,486) = 7.358 (p<0.001)			F(5, 486) = 7.443 (p<0.001)		

Table 5. Two lines test results

	Average slope 1			Average slope 2		
Male	b	z	Sig	b	z	Sig
Right hand digit ratio	-5.35	-.3.35	0.0008	1.9	1.64	0.1004
Left hand digit ratio	-3.2	-2.02	0.0437	2.32	1.63	0.1028

Female						
Right hand digit ratio	-0.37	-0.42	0.6736	0.3	0.52	0.5996
Left hand digit ratio	-0.86	-0.91	0.364	-0.03	-0.02	0.9832

Table A1. Confirmatory tetrad test results

	t statistics	P Values	Lower CI	Upper CI	Bias corrected Lower CI	Bias corrected Upper CI
1: envhabit1,envhabit10,envhabit2,envhabit3	0.128	0.899	-0.022	0.025	-0.037	0.040
2: envhabit1,envhabit10,envhabit3,envhabit2	0.373	0.709	-0.038	0.028	-0.058	0.049
4: envhabit1,envhabit10,envhabit2,envhabit4	0.688	0.492	-0.019	0.038	-0.038	0.056
6: envhabit1,envhabit2,envhabit4,envhabit10	2.923	0.004	**-0.036**	**-0.007**	-0.045	0.002
7: envhabit1,envhabit10,envhabit2,envhabit5	1.554	0.121	-0.004	0.027	-0.014	0.037
10: envhabit1,envhabit10,envhabit2,envhabit6	1.770	0.077	-0.003	0.044	-0.017	0.059
13: envhabit1,envhabit10,envhabit2,envhabit7	0.396	0.692	-0.035	0.022	-0.052	0.039
17: envhabit1,envhabit10,envhabit8,envhabit2	0.353	0.724	-0.009	0.006	-0.013	0.010
20: envhabit1,envhabit10,envhabit9,envhabit2	0.008	0.994	-0.012	0.011	-0.019	0.018
29: envhabit1,envhabit10,envhabit6,envhabit3	0.628	0.531	-0.017	0.033	-0.032	0.048
31: envhabit1,envhabit10,envhabit3,envhabit7	0.056	0.955	-0.052	0.060	-0.088	0.095
35: envhabit1,envhabit10,envhabit8,envhabit3	0.944	0.346	-0.018	0.006	-0.025	0.013
41: envhabit1,envhabit10,envhabit5,envhabit4	0.239	0.811	-0.030	0.022	-0.046	0.039
43: envhabit1,envhabit10,envhabit4,envhabit6	0.138	0.890	-0.032	0.027	-0.051	0.046
47: envhabit1,envhabit10,envhabit7,envhabit4	1.432	0.153	-0.011	0.060	-0.033	0.083
50: envhabit1,envhabit10,envhabit8,envhabit4	0.150	0.881	-0.016	0.017	-0.026	0.028
60: envhabit1,envhabit5,envhabit7,envhabit10	2.065	0.039	**0.000**	**0.045**	-0.013	0.059
64: envhabit1,envhabit10,envhabit5,envhabit9	1.556	0.120	-0.005	0.044	-0.021	0.060
66: envhabit1,envhabit5,envhabit9,envhabit10	1.176	0.240	-0.041	0.010	-0.057	0.026
71: envhabit1,envhabit10,envhabit8,envhabit6	0.290	0.772	-0.028	0.020	-0.043	0.035
80: envhabit1,envhabit10,envhabit9,envhabit7	0.004	0.997	-0.017	0.016	-0.027	0.026
91: envhabit1,envhabit2,envhabit3,envhabit6	0.976	0.329	-0.075	0.026	-0.107	0.058
120: envhabit1,envhabit5,envhabit6,envhabit2	0.649	0.517	-0.018	0.009	-0.027	0.018
169: envhabit1,envhabit3,envhabit5,envhabit8	2.247	0.025	**0.006**	**0.096**	-0.023	0.125
182: envhabit1,envhabit3,envhabit9,envhabit6	2.094	0.037	**0.003**	**0.136**	-0.039	0.178
205: envhabit1,envhabit4,envhabit6,envhabit7	0.475	0.635	-0.054	0.034	-0.082	0.062
233: envhabit1,envhabit5,envhabit8,envhabit7	0.967	0.334	-0.017	0.049	-0.038	0.070
236: envhabit1,envhabit5,envhabit9,envhabit7	2.351	0.019	**0.007**	**0.069**	-0.013	0.089
248: envhabit1,envhabit6,envhabit9,envhabit8	1.467	0.143	-0.115	0.015	-0.156	0.057
281: envhabit10,envhabit2,envhabit8,envhabit4	4.589	0.000	**-0.076**	**-0.030**	**-0.091**	**-0.016**
324: envhabit10,envhabit4,envhabit7,envhabit3	2.573	0.010	**-0.067**	**-0.009**	-0.085	0.009
358: envhabit10,envhabit3,envhabit8,envhabit9	0.463	0.643	-0.066	0.038	-0.098	0.071
395: envhabit10,envhabit5,envhabit8,envhabit6	4.639	0.000	**-0.123**	**-0.049**	**-0.147**	**-0.026**
434: envhabit2,envhabit3,envhabit9,envhabit4	2.866	0.004	**-0.055**	**-0.010**	-0.069	0.004
526: envhabit3,envhabit4,envhabit5,envhabit6	1.023	0.307	-0.064	0.021	-0.091	0.047

Figure captions

Figure 1. Result plot from the male right hand digit ratio two lines test

Figure 2. Result plot from the male left hand digit ratio two lines test