Digit Extension: validation of a new biometric variable.

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Abstract

This paper reports on a new biometric variable, namely digit extension. We calculated the average length of the second and fourth digit rather than their ratio and we entitled this biometric digit extension. In a first study, we showed that digit extension is related more strongly to a self-concept associated with vigor (masculine trait) than with supportiveness (feminine trait) in men, but not in women. In a second study we found that digit extension and risk seeking (masculine trait) were related in men, but not in women. In a third study we found that for both men and women a higher digit extension was related to more altruistic behavior in a situation where it is in accordance with either masculine or feminine traits. For all studies we show divergent validity with digit ratio, indicating that digit extension is independent of digit ratio. We speculate about the hormonal influences that determine digit extension.

Keywords: digit extension, finger lengths, masculinity, risk seeking, altruism

Introduction

In recent years, the so-called second (2D) to fourth (4D) digit ratio has received a lot of research attention. In the past 5 years, many papers have documented relations between 2D:4D and human traits and behaviors. This ratio seems to be established in utero (Csatho et al. 2003; Manning et al., 1998; Williams et al., 2003). Some evidence suggests that the index finger (digit 2) is an indicator of prenatal estrogen levels while the length of the ring finger (digit 4) appears to be determined by prenatal testosterone levels (Manning, 2002). Although both digits could be investigated in isolation as they would indicate different hormones, research typically looks at the correlates of the ratio between 2nd and 4th digit (2D:4D). There are some exceptions to this general practice. For instance, Robinson and Manning (2000) found an association between homosexuality and the 4th, but not the 2nd digit (controlled for height); Manning & Wood (in Manning, 2002) report that boys with long 4th digits adjusted for height reported more physical aggression compared to participants with short 4th digits.

It is remarkable that this 2D:4D ratio is determined by the relative level of two hormones. Investigating the correlates of the two relevant digits separately seems one straightforward way to deepen our knowledge about the effects of prenatal hormone levels. However, the 2D:4D literature suggests that the balance between male and female prenatal hormone levels rather than these hormone levels in isolation triggers neurological and behavioral processes (for a recent overview, see Manning, 2002).

The growing list of psychological correlates of 2D:4D and the short list of psychological correlates with the digits separately may suggest that investigating the main effects of one sexual hormone might not make too much sense without taking into account the other hormone level. Note that this remark applies to the role of hormone levels *in utero* and does not necessarily generalize to fluctuating hormone levels.

In spite of its predictive success the 2D:4D variable leaves one degree of freedom unexplored. This paper attempts to fill this empirical gap. In this paper, we look at the overall level of sexual hormones during early development, independently of the relative levels of male and female hormones. To our knowledge, a synergetic effect of both hormones has not been investigated yet. The appropriate metric that captures the joint effect of prenatal testosterone and estrogens seems to be the average absolute length of index and ring fingers or (2D+4D)/2. We call this measure *'digit extension'* and we label the abbreviation ‘DE’. At this point, we prefer to focus on those two digits because less is known about the determinants of the length of the other fingers (e.g. Manning 2002).

This paper is largely explorative with respect to substantial hypotheses. Proposing firm hypotheses relying on the diverse literatures documenting on 2D:4D (e.g. Manning, 2002), testosterone levels (stable and fluctuating, e.g. Mazur & Booth, 2002; Olweus et al., 1988), and estrogen levels (stable and fluctuating, e.g. DeSoto et al., 2003; Morgan et al., 2004) would be speculative at best because it is unclear which effect will dominate, or whether one effect would dominate at all. In this paper, we report three studies in which we explore whether digit extension is associated with typically masculine characteristics (dominated by ‘testosterone’ traits), with typically feminine characteristics (dominated by ‘estrogen’ traits), and whether these associations are sex specific. In the first study, we explore the relation between respondents’ digit extension on the one hand and being more vigorous (a typically masculine attribute) versus being more supportive (a typically feminine attribute; see Lueptow et al., 1995) on the other hand. In this study, we use implicit measures to prevent normative and self-presentational influences to distort the relationship. We found that digit extension is associated more to a preference for vigor over supportiveness as a self-descriptive label for men but not for women. In study 2, we extend this exploration toward risk seeking. Risk seeking can be considered as a signal of vigor (Farthing, 2005) for men. We find that men but not women with a high digit extension are more risk seeking. In the final study, we explore whether digit extension is also predictive of altruistic behavior. Altruistic behavior may, in some circumstances, be considered as risk seeking (a typically masculine characteristic), but also as supportive behavior (a typically feminine characteristic). Consistently, this study shows that digit extension is related to higher levels of altruistic behavior both in men and in women.

Study 1: Vigor vs. Supportiveness and Digit Extension.

We want to explore whether a higher digit extension would be associated with a greater display of a) masculine traits (e.g. vigor), b) feminine traits, (e.g. supportiveness) or c) masculine traits for men and feminine traits for women. To measure differences in the display of mainly masculine compared to mainly feminine traits, we make use of a self-concept measurement of vigor and supportiveness. The self-concept is typically the result of long series of self-observations (Bem, 1969) and is more robust to situational fluctuations than isolated one-shot observations. The most popular way to measure self-concept are self-report measures. However, self-report measures suffer from some serious shortcomings, such as the respondent's inability to introspect and unwillingness to honestly report on sometimes less desirable traits (Greenwald & Farnham, 2000). Therefore, we relied on an implicit measurement method: the so-called Implicit Association Test or 'IAT' (Greenwald et al., 1998). The IAT is a computerized task that measures strengths of automatic associations between concepts by interpreting response times. The method has been proven to be a valid and stable measure of implicit self-concept (Greenwald & Farnham, 2000). Greenwald et al. (2002) define self-concept as the association of the concept of self with one or more attribute concepts. This implies that, on average, strong men will especially associate concepts indicating 'vigor' (e.g. strong) with concepts indicating 'self' (e.g. me) whereas supportive men will associate concepts indicating 'supportiveness' (e.g. caring) with concepts indicating 'self'. Stronger associations lead to faster reaction times. A substantial number of studies have demonstrated the reliability and validity of the IAT (overview in Greenwald & Nosek, 2001). Park and Schaller (2005), for instance, have used the IAT to measure kin perception.

We are interested in the relation between digit extension and an either positively masculine (vigor) or positively feminine (supportiveness) self-concept, and whether this association is sex specific. We use positive gender-related traits because people have the tendency to associate the self with desirable traits (Rudman et al., 2001).

Participants and procedure

One hundred and four students of different departments (65 women, 39 men), between 18 and 33 years, participated in the study in exchange for a 6-euro reimbursement. The present study was imbedded in a series of unrelated studies.

Upon arrival in the lab, respondents first completed a 5 block computer-based IAT measuring respondents' self-concept with respect to supportiveness and vigor. Second, the right-hand finger lengths of each respondent were measured. For the IAT, Inquisit laboratory software and PC-type desktop computers were used. The experiment was conducted individually and took about 15 minutes.

IAT. The self-concept IAT was designed to measure the association between the self and vigor relative to the association between self and supportiveness. The target concepts in the IAT were self (me, mine, my, self) versus others (others, they, them, their). As attribute stimuli, we used words referring to vigor (powerful, strong, self-confident, dominant, solid, authority, assertive) and words referring to supportiveness (warm, educated, friendly, love, caring, gentle, sweet). In the first block, respondents discriminated between words referring to 'supportiveness' and 'vigor' on 24 trials. In block 2 respondents discriminated between words referring to 'self' and 'other' on 24 trials. In Block 3 (24 practice and 48 data collection trials) respondents were asked to categorize items by pressing one of the two keys (words referring to 'self' and words referring to 'vigor' assigned to one key versus words referring to 'others' and words referring to 'supportiveness' assigned to the other key). Block 4 was identical to block 2 except for the side of the key combinations. Block 5 was identical to block 3 but with a reversed categorization task. Consistent with the literature (e.g. Greenwald et al. 1998) we counterbalanced (key – category combinations and order of the combinations) as appropriate. Only the data of the data collection trials (blocks 3 & 5) were used for analysis. Before and during each phase, category labels (self, others, supportiveness and vigor) were displayed on the left and right sides of the screen. Respondents were asked to respond as quickly and accurately as possible. All blocks were respondent-initiated. In case of an incorrect response, a red cross appeared on the screen for 400 ms.

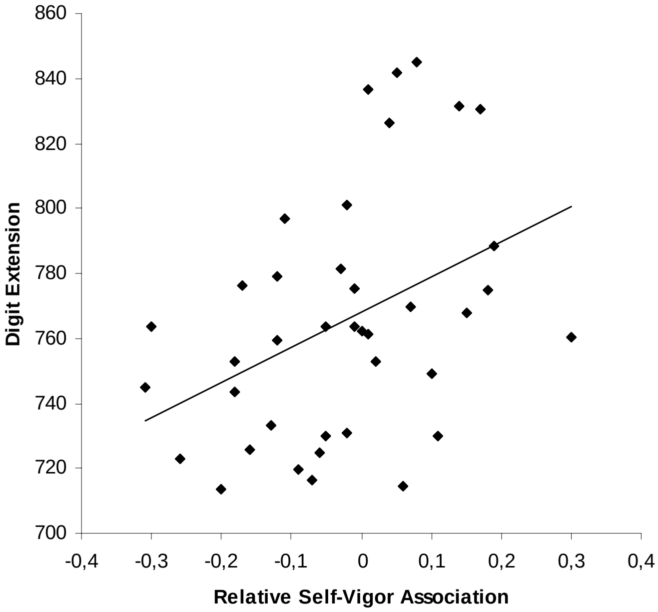
Prior to analysis, IAT data were treated following the procedure outlined by Greenwald et al. (1998): (1) reaction times shorter than 300 ms and larger than 3000 ms were recoded into 300 ms and 3000 ms respectively, (2) the first two trials of each block were dropped because of their typically longer latencies, as were reaction times and trials with an incorrect response and (3) reaction times were log-transformed prior to averaging. However, for reasons of clarity, response latencies in terms of milliseconds will be reported (see Greenwald et al., 1998). The average error rate was 5.73 % (.00% - 33.70%). We excluded one respondent from the analysis because of an average error rate larger than 30% (Cfr. Maison et al., 2001). We calculated the IAT-effect by subtracting the mean response time for performing the self+vigor/others+supportiveness task from the mean response time for completing the self+supportiveness/others+vigor task. As a result, positive scores indicate a stronger association between the self and vigor than between the self and supportiveness, we further refer to this variable with the term ‘relative self-vigor association’.

Finger lengths. The right-hand was scanned to measure finger lengths. Participants placed their hand palms on the centre of the glass plate of a scanner. We ensured that details of major creases could be seen on the scans. Afterwards, lengths of the second and fourth digits were measured from the ventral proximal crease of the digit to the finger tip by means of an Adobe® Photoshop 7.0 tool. We measured from the most proximal crease when there was a band of creases at the base of the digit. Using scanned pictures seems a valid method to measure finger lengths (Williams et al., 2003; Bailey & Hurd, 2005). The lengths of index (2D) and ring (4D) fingers were measured by two independent raters. Ratings were conducted blind to the other measures. To assess reliability, we correlated both measures of finger lengths. These correlations were .995 for 2D and .997 for 4D. Accordingly, the correlation between digit ratios was .978 and between digit extensions .997.

Results and discussion

We conducted an ANOVA with relative self-vigor association as the dependent variable and digit extension, gender and their interaction as the independent variables. Men (M = -16 ms, SD =116.76) scored higher on relative self-vigor association than women (M =-81 ms ,SD = 112.87; F (1, 99) = 3.92, p = .05. Additionally, we found a significant interaction between gender and digit extension (F (1, 99) = 4.55, $p < .04$). To gain more insight, we looked at the correlation between digit extension and relative self-vigor association for each sex separately. We found a positive correlation between digit extension and relative self-vigor association for men (r = .33, n = 38, $p < .05$), but not for women (r = -.09, n = 65, p = .50). Figure 1 shows the relation for the male participants.

Figure 1. Digit Extension (mm) as function of Relative Self-Vigor Association in men



To establish discriminant validity from digit ratio, we also looked at the correlation with 2D:4D. Digit ratio and digit extension were not related in men (*r* = .13, *n* = 38, *p* = .45), nor in women (*r* = -.08, *n* = 65, *p* = .56). Moreover, when we controlled the correlations between digit extension and the relative self-vigor association for digit ratio, these correlations did not change (for men and women resp. *r* = .33, *p* = .05 and *r* = -.08, *p* = .55). Additionally, when we correlated digit ratio and relative self-vigor association, we did not find any effect, neither for men (*r* = .15, *p* = .66), nor for women (*r* = .15, *p* = .23). The relative self-vigor association appears unrelated to the 2D:4D. This evidence supports the idea that digit extension is independent from digit ratio.

To conclude, our findings suggest that higher digit extensions, reflecting joint high levels of prenatal testosterone and estrogen levels, are more related to a self-vigor association compared to a self-supportiveness association in men but not in women. However, part of this relation might rely on height differences. In the next studies we therefore controlled for participants' height.

Study 2: Digit Extension and Risk-seeking.

According to Farthing (2005), Costly Signaling Theory suggests that some risk taking behaviors may signal male's health and vigor to potential mates. As the implicit self-vigor association may indicate vigor (for men), we expect that higher male digit extension should be related to higher levels of risk-seeking. Therefore, we expect a similar interaction as in study 1 between digit extension and sex on risk-seeking: Higher digit extension should be related to more risk-seeking tendency for men but not for women.

Participants and procedure

One hundred sixty five undergraduate economics students (82 women, 83 men), between 18 and 25 years participated in exchange for course credit.

Risk-seeking tendency. We used 8 'choice problems' as described in Kahneman and Tversky (1978). For every problem, participants had to choose between two options: a more and a less risky one. For each 'problem' (see Appendix) we scored the risk-seeking choice as 1 and the other as 0. Afterwards we summed the 8 values to obtain a 'risk-seeking score': higher scores reflect higher levels of risk-seeking tendency (or risk proneness).

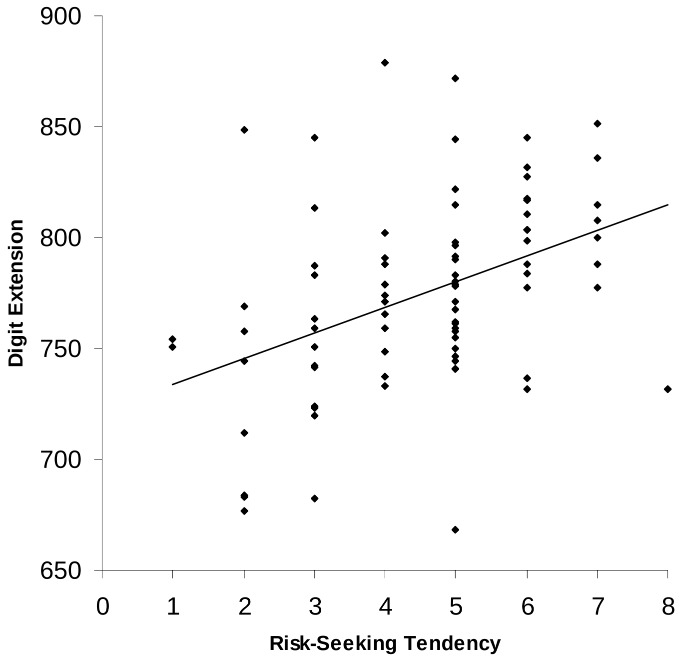
Digit extension and height. We measured digit lengths in exactly the same manner as in study 1. Again, lengths of 2D and 4D were measured by two independent raters. Ratings were conducted blind to the other measures. The correlations between the two raters were .995 for 2D and .995 for 4D. Accordingly, the correlation between digit ratio's was 0.956 and between digit extensions 0.997. We asked participants for their height.

Results

We conducted an ANOVA with risk-seeking tendency as the dependent variable, and with digit extension, gender and their interaction as the independent variables. Consistent with literature (e.g. Farthing 2005), men (M = 4.54, SD = 1.57) scored higher on risk-seeking than women (M = 3.91, SD = 1.44, F (1, 161) = 8.36, $p < .005$). Additionally, we found a significant main effect of digit extension (F (1, 161) = 4.85, $p < .03$): digit extension was positively related to risk-seeking tendency (r = .29, $p <$ .001). However this effect was again qualified by a significant interaction with sex (F

(1, 161) = 8.57, $p < .005$). We found a similar correlation pattern as in Study 1: a positive correlation between digit extension and risk-seeking tendency for men ($r = .42$, $n = 83$, $p < .001$), but no correlation for women ($r = -.05$, $n = 82$, $p = .64$).[1] Figure 2 shows the relation for men.

Figure 2. Digit Extension (mm) as a function of Risk-Seeking Tendency (men).



Digit ratio and digit extension were not related in men ($r = -.14$, $n = 83$, $p = .21$), nor in women ($r = -.06$, $n = 82$, $p = .62$). Moreover, controlling the correlations between digit extension and risk-seeking tendency for digit ratio did not affect their size (for men and women respectively $r = .41$, $p < .001$ and $r = -.05$, $p = .66$)[2]. Additionally, there was no correlation between digit ratio and risk-seeking tendency, neither for men ($r = -.06$, $p = .59$), nor for women ($r = .05$, $p = .67$). As in Study 1, these findings strongly suggest that digit extension is a biometric that is independent from digit ratio.

[1] Dividing digit extension by height decreased the effect in men slightly, but it remained significant (men: $r = .25$, $n = 83$, $p < .03$; women: $r = -.094$, $n = 82$, $p = .40$).

[2] Dividing digit extension by height and controlling for digit ratio, the correlation between digit extension and risk-seeking decreased slightly in men, but remained significant (men: $r = .24$, $n = 83$, $p < .03$; women: $r = -.095$, $n = 82$, $p = .40$).

Study 3. Altruistic behavior and Digit Extension.

The findings from our first two correlational studies provide evidence for a link between digit extension on the one hand and vigor (implicit) and risk-seeking (explicit) on the other hand in men. It appears that digit extension is related to vigor in men. We have been less successful in finding behavioral correlates of digit extension in women. Women with a high digit extension might not only be more supportive but also more vigorous than women with a low digit extension. This is a pattern that our relative measure in Study 1 cannot reveal, and that might reduce the relation with risk seeking in Study 2 for women. In this study we used a behavioral measure that can be defined both in terms of vigor and in terms of supportiveness: altruism. Altruism is distinguished from cooperativeness: it implies going beyond the norm of cooperativeness. In study 3 we looked at altruistic behavior, because altruism can be enhanced by both risk seeking tendencies and high levels of supportiveness. In this study, we reanalyzed data from a recently published paper in which the authors investigated the link between cooperative behavior and 2D:4D (Millet & Dewitte, in press). The typical public good game was slightly adapted such that it allowed the differentiation between altruistic and cooperative behavior. Participants were exposed (as an observer) to a group that was trying to obtain the public good. After two collective failures to reach the public good, participants had to join this group. In such a situation, there are three reasonable options. Players can contribute either more than (= altruistic behavior), exactly the same as (=cooperative behavior), or less than the norm prescribes (= egoistic behavior). The message of that paper was that a low 2D:4D was related to cooperative behavior and a high 2D:4D to both egoistic and altruistic choices. In the social dilemma situation just described, altruistic behavior is more risk-seeking as well as more supportive than either cooperative or egoistic behavior. The altruistic choice is more risk-seeking than the other options because of the uncertain nature of the other players' reaction to a group failure. The altruistic choice is also more supportive than the other two options because it represents a higher contribution to the others. Based on the first two correlational studies we predict that men who behave altruistically have a higher digit extension compared to those who behave either egoistically or cooperatively. For women, a similar pattern would be consistent with one of our initial assumptions that a high digit extension reflects a more sex-specific profile, for which we failed to find support so far in women.

Participants and procedure

Seventy undergraduate students (43 women and 27 men) aged between 18 and 23 participated in the experiment. The monetary reward depended on their performance (with a minimum of 5 euro).

A social dilemma situation was created, namely a repeated public good game with four players. In this game, decisions were made simultaneously and involved contributing a certain amount to the provision of a public good. The provision point, necessary to obtain the good, was always 100 points. At the beginning of each round, all participants received an endowment of 40 points. In each round, they had to decide how much of the endowment they would invest in the public good or keep for themselves. Every point was worth 3.39 eurocent. All the points that were invested, were subtracted from their 40 points endowment. If the public good was obtained (100 points), 160 points were distributed equally across the four players in that round, irrespective of their individual contributions. The norm equals the provision point divided by the number of players. In a pre-test describing the public good situation ($N = 32$) participants from the same population were asked what a player should do in this situation. Ninety-seven percent answered that one should invest 25 points, which suggests that this is indeed the appropriate behavior in this situation.

Upon arrival in the laboratory, each participant was assigned to a computer in a partially enclosed carrel. Participants did not see one another and did not talk to each other. They believed that they played a game involving six people, but in reality they played against the PC. It was told that four of the six participants were players in the game, and that two others were observers of the game. The observers did not play themselves. They were told that the roles of player and observer could change during the game.

All participants started as an observer. They twice observed that the good was not obtained. The shortage was 5 (out of 100) points in the first round and 2 points (out of 100) in the second. They did not receive information about individual contribution levels. After the first two rounds, participants replaced one person in the game and had to decide how much they invested in the public good. As the group had twice failed to reach the public good, the third round was a very uncertain situation. Three behavioral categories, defined in relation to the appropriate contribution level of 25 points, i.e. the provision point divided by the number of players were distinguished. Participants could contribute either exactly the fair share (= cooperative decision), less than the fair share (= egoistic decision), or more than the fair share (= altruistic decision). We measured participants' decisions (cooperative, egoistic or altruistic) in the first round that they played (i.e. the third round of the game).

Digit extension and height. The right-hand was scanned to measure finger lengths. The lengths of index (2D) and ring (4D) fingers were measured two times by the same rater with a time span of ten weeks. The two measurements of digit extension were highly correlated ($r = .998$, $p < .0001$). In the analysis, we used the average between the two measurements. An independent rater also measured finger lengths. Ratings were conducted blind to the participants' decision and gender. To assess reliability, we correlated the compound and independent measurement of finger lengths. These correlations were .993 for 2D and .998 for 4D. Accordingly, the correlation between digit ratios was .965 and between digit extensions .998. Participants were asked to indicate their height.

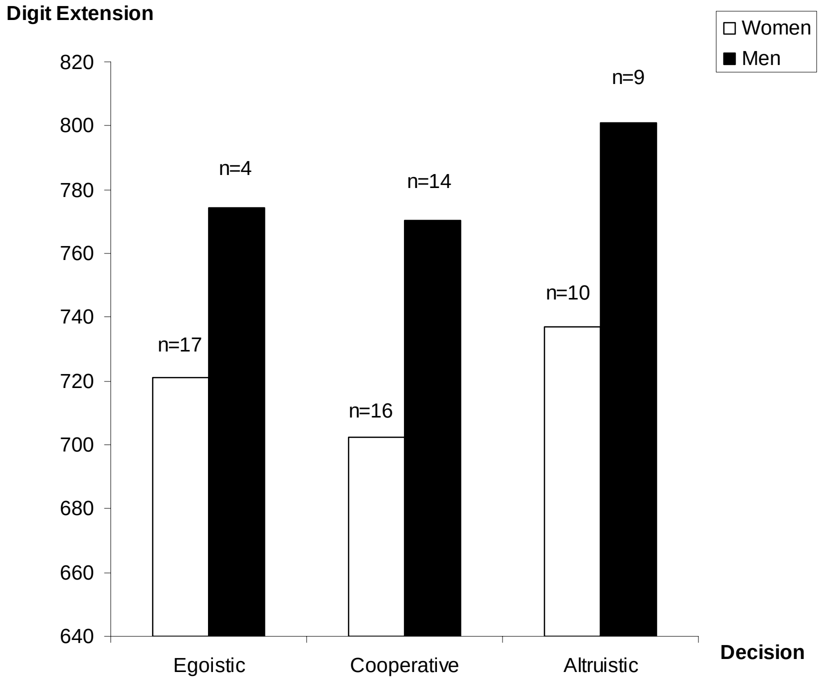
Results

Thirty participants acted cooperatively, 19 altruistically and 21 egoistically. We performed a 2 (Sex) by 3 (Public Goods Choice) factorial Anova with digit extension (in mm) as the dependent variable to examine our hypothesis. We found a significant main effect of Sex ($M_{men} = 78.13$, $SD_{men} = 3.61$ vs. $M_{women} = 71.77$, $SD_{women} = 3.40$; $F\ (1, 64) = 48.57$, $p < .001$) and a significant main effect of Public Goods Choice ($M_{egoistic} = 73.09$, $SD_{egoistic} = 3.67$; $M_{cooperative} = 73.43$, $SD_{cooperative} = 4.51$; $M_{altruistic} = 76.73$, $SD_{altruistic} = 5.11$; $F\ (2, 64) = 5.64$, $p < .006$)[3]. Participants who acted altruistically, in contrast to participants acting egoistically or cooperatively had a higher digit extension ($M_{altruistic} = 76.73$, $SD_{altruistic} = 5.11$; $M_{others} = 73.29$, $SD_{others} = 4.15$; $F\ (1, 64) = 8.29$, $p < .006$). The interaction between Sex and Public Goods Choice did not approach significance ($F\ (2, 64) = .20$, $p = .82$; see Figure 3). The

[3] We repeated all analyses with digit extension divided by height as the dependent variable. We did not find any effect of sex ($M_{men} = 0.043$, $SD_{men} = 0.002$ vs. $M_{women} = 0.043$, $SD_{women} = 0.002$; $F\ (1, 64) = 1.38$, $p = .25$), but a strong significant main effect of Public Goods Choice ($M_{egoistic} = 0.042$, $SD_{egoistic} = 0.002$; $M_{cooperative} = 0.042$, $SD_{cooperative} = 0.001$; $M_{altruistic} = 0.044$, $SD_{altruistic} = 0.002$; $F\ (2, 64) = 5.91$, $p < .005$). Participants who acted altruistically, in contrast to participants acting egoistically or cooperatively had a higher relative digit extension ($M_{altruistic} = 0.044$, $SD_{altruistic} = 0.002$; $M_{others} = 0.042$, $SD_{others} = 0.002$; $F\ (1, 64) = 9.46$, $p < .004$).

relation between high digit extension and altruistic behavior was similar and significant (p's $< .05$) for both sexes.

Figure 3. Digit Extension (mm) as a function of Public Goods Choice.



Digit ratio and digit extension were not related in men (r = -.30, n = 27, p = .12), nor in women (r = .05, n = 43, p = .46). Moreover, a logistic regression with altruistic behavior as the dependent variable (yes vs. no) and digit extension as the independent variable and controlling for digit ratio and sex, revealed a highly significant effect of digit extension (digit extension: $\chi^2 = 8.56$, $p < .004$; digit ratio: $\chi^2 = 5.80$, $p < .02$; sex: $\chi^2 = .44$, $p = .51$)[4]. Again, these findings illustrate the independent nature of digit ratio and digit extension.

[4] Divided digit extension by height produced similar results *(relative digit extension:* $\chi^2 = 10.99$, $p < .002$; digit ratio: $\chi^2 = 7.39$, $p < .008$; sex: $\chi^2 = 2.17$, $p = .14$).

General discussion

This paper reports on the initial validation of a new biometric variable with behavioral correlates: digit extension. We found that at least for men, a high digit extension was related to an implicitly perceived relative self-vigor association and to a higher risk-seeking tendency. Further, a behavioral experiment showed that digit extension was also related to altruistic behavior . The latter finding did not only apply to men, but also to women, consistent with the view that altruism requires either vigor or supportiveness. In the remainder we summarize the statistical properties of digit extension, briefly speculate about the origin of the effect, and conclude by suggesting avenues for future research.

Because this is the first paper on digit extension and that the paper reports data of over 300 participants, it might be useful to provide an overview of the simple statistics of the new biometric, and its relation to the well-established 2D:4D and the separate lengths of the second and the fourth digit. We summarized most important descriptives in Table 1.

Table 1. Descriptive statistics (men/women, lengths are expressed in millimetres)

	N[a]	M	SD	Range	Min	Max	r(X;2D)	r(X;4D)	r(X; 2D:4D)
2D:4D	149/190	.9558/.9682[b]	.0244/.0323	.1290/.1661	.8843/.8815	1.0133/1.0476	.15/.28[b]	-.32/ -.34	1/1
2+4D	149/190	77.61/71.53[b]	4.15/3.65	21.08/24.21	66.81/61.05	87.89/85.26	.97/.95	.98/.95	-.10/ -.04
2D	149/190	75.83/70.35[b]	4.09/3.74	20.20/23.50	66.40/60.30	86.50/83.80	1/1	.89/.81	.15/.28
4D	149/190	79.38/72.71[b]	4.44/3.94	22.26/24.89	67.23/61.81	89.49/86.70	.89/.81	1/1	-.32/ -.34
Height	110/125	1823/1690[b]	67/62	350/400	1650/1520	2000/1920	.49/.52	.49/.54	-.07/-.04
2+4D/Height	110/125	.0426/.0424	.0020/.0018	.0110/.0101	.0370/.0377	.0480/.0478	.72/.65	.73/.64	-.15/.01
2D/Height	110/125	.0417/.0416	.0020/.0019	.0099/.0123	.0368/.0360	.0467/.0483	.74/.72	.63/.47	.13/.38
4D/Height	110/125	.0435/.0431	.0022/.0019	.0127/.0111	.0370/.0381	.0497/.0492	.65/.50	.77/.72	-.39/-.35

[a] for all columns the first figure refers to men and the second to women

[b] Gender difference is significant at the .01 level (tested for means)

In line with previous research (e.g. Manning et al., 1998) we observe that a higher 4D is associated with a lower, more male typical, 2D:4D and a higher 2D is associated with a higher, more female typical, 2D:4D. This provides support to the idea that 4D would especially be related with more male typical pre-natal hormone levels, while 2D may be related with more female typical pre-natal hormone levels. As shown is in many previous studies (e.g. Coolican & Peters, 2003; McFadden & Shubel, 2002), we replicate the sexual dimorphism of 2D:4D with men having lower values than women. Digit extension on the other hand does not show sexual dimorphism when corrected for height: digit extension is (on average) 4.2 % of absolute height.

Digit extension is statistically independent from 2D:4D. The correlation between 2D:4D and digit extension is close to zero, and the present three studies suggest that their correlates are not overlapping. This has several implications.

Our findings indicate that digit extension and 2D:4D are determined by different processes. If not, we should have found correlations between both variables (e.g. when 4D would be determined by testosterone and 2D would be a proxy for height, digit extension and 2D:4D should be strongly negatively related). However, the question remains what exactly is behind digit extension. At the most basal level, both biometrics are at least for a large part determined by hox genes as these influence - among other things - digit formation (Goodman & Scambler, 2001; Kondo et al., 1997). Further, Manning and Bundred (2000) stated that the link between prenatal estrogen, testosterone and digit formation may lie in the action of hox genes as they are also essential for the differentiation of the urinogenital system (including testes and ovaries). Hox genes are involved in control of cell growth and when dysregulated, in oncogenesis. Therefore it has been suggested that 2D:4D may be correlated with many sex-dependent diseases with origins in fetal programming (Manning et al., 2003). As digit extension is probably also influenced by hox gene activity and we find associations with sex-specific behavior independent of 2D:4D, this biometric variable may add value to the hypothesized use of digit ratio as a susceptibility indicator of some (sex-dependent) diseases. Moreover, extreme digit length has already been identified as a symptom the Marfan syndrome, a disease characterized by skeletal abnormalities such as long limbs and digits (Collod-Béroud & Boileau, 2002; McLellan et al., 1994). To summarize, although we do not know what and how exactly digit extension is determined, our data invite research that explores the role of digit extension in the predisposition and prognosis of diseases.

In addition, like we already mentioned, we find that digit extension is associated with masculine traits in men. Literature also suggest that 2D:4D is associated with masculinity (Csatho et al., 2003) and is sex dependent (e.g. Manning, 2002). This suggests that masculinity has more than one facet. The recent finding that 2D:4D was not related to typical masculine features such as facial masculinity, body masculinity and combined testes volume (Koehler et al., 2004) is consistent with the suggested bifaceted nature of masculinity. The present data do not allow to make a similar reasoning for women. We call for future research that explores the differential behavioral and psychological effects of both biometrical variables in both women and men. We conclude by inviting researchers to reanalyze old datasets containing digit ratio and look for meaningful associations with digit extension.

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Appendix

Choose between the two options, assume that each point is valuable

1) A. 33 % chance on 2500 points;
   66 % chance on 2400 points;
   1 % chance on 0 points;
   B. 2400 points with certainty;

2) A. 33 % chance on 2500 points;
   67 % chance on 0 points;
   B. 34 % chance on 2400 points;
   66 % chance on 0 points;

3) A. 80 % chance on 4000 points;
   B. 3000 points with certainty;

4) A. 25 % chance on 4000 points;
   B. 25 % chance on 3000 points;

5) A. 50 % chance to win a three-week tour of England, France and Italy;
   B. A one-week tour of England, with certainty;

6) A. 5 % chance to win a three-week tour of England, France and Italy;
   B. 10 % chance to win a one-week tour of England;

7) A. 45 % chance on 6000 points;
   B. 90 % chance on 3000 points;

8) A. 0.1 % chance on 6000 points;
   B. 0.2 % chance on 3000 points;