

DIGIT RATIO (2D:4D) PREDICTS COMMUNION IN EXPLORATORY
STRUCTURAL EQUATION MODELING OF SELF-NARRATIVES

by

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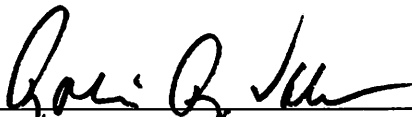
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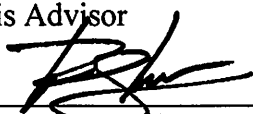
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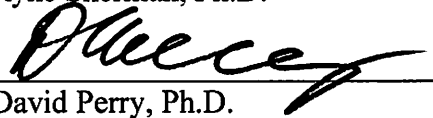
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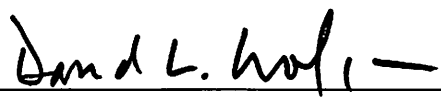
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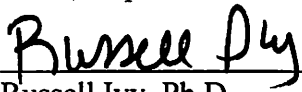
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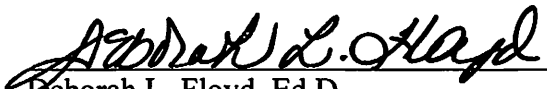

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ABSTRACT

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Agency and communion are fundamental dimensions underlying psychological processes. Although agency and communion are coherent dimensions, their origins, nature, stability differ across theoretical framework. Common to these frameworks are gender differences in agency and communion. The present study hypothesized that because agency and communion relate to gender, they may also relate to digit ratio. The present study is important because digit ratio may offer clues on the origins and nature of agency and communion, and their gender differences. Agency and Communion factors were extracted from implicit linguistic measures obtained by LIWC analysis of self-narratives. Exploratory structural equation modeling indicated communion related to digit ratio in men, and gender differences in communion. Although the results supported the distal, biological influences of communion argued by evolutionary accounts, the null finding agency was not related to digit ratio, while not directly interpretable, did not contradict socialization accounts of agency.

DEDICATION

To my dad, who gives me the gift of time, and to my mother, whose sensibilities and spirit echo in my own.

To my sister, Colee, who for all her wisdom and charm, will always be my fellow monster.

To my friends, Andy and Joey, whose laughter and good spirits I do so appreciate.
And to my darling, Shrija, who brings light and life to my world, and whose love is so wonderfully familiar.

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INTRODUCTION

Agency and communion are prevalent dimensions in self-narratives. Although between-gender differences are commonly observed in agency and communion, few studies have examined predictors of within-gender variability. The present study examined the association between implicit measures of agency and communion and digit ratio. To explain this association, it serves to broadly explore what agency and communion are. The present study's research question has implications for important issues of the nature, origin, and relationship between agency and communion.

Agency and communion as fundamental dimensions

Agency and communion are fundamental dimensions underlying psychological processes. Though first proposed by Bakan (1966, p.14) as modalities, the discovery of agency and communion in unrelated fields led to their proliferation as traits, beliefs, motives, narrative themes, values, interpersonal behavior, and social judgments (Abele & Wojciszke, 2007; Hogan, 1982; Judd, James-Hawkins, Yzerbyt, & Kashima, 2005; Foa, 1961; McAdams, 1985; McCrae & Costa, 1989; Wiggins, 1991).

As modalities, Bakan (1966, p.15) defined agency as self-protection, self-assertion, and self-expansion, and communion as union, connectedness, and cooperation. As traits, agency and communion are, respectively, rotational variants of extraversion and agreeableness (McCrae & Costa, 1989), the axes encompassing dominance and

nurturance of the interpersonal circumplex (Leary, 1957; Wiggins, 1991; Wiggins & Trapnell, 1996), and akin to Big Five superfactors Beta and Alpha reflecting self-actualization and socialization (Blackburn, Renwick, Donnelly, & Logan, 2004; Digman, 1997). As motives, agency and communion underlie, respectively, power and intimacy (McAdams, 1985; Peterson & Stewart, 1993), and status and popularity (Hogan, 1982). Lastly agency and communion appear in social judgments, respectively, as perceptions of intelligence, competence, ability, and warmth, friendliness, trustworthiness (Fiske, Cuddy, & Glick, 2006; Judd et al., 2005).

Although agency and communion are coherent dimensions, there is a gamut of views on their basic properties. Leonard (1997) observed two general approaches to modeling the relationship between agency and communion. Trait and social cognition theorists view them as negatively related (Bakan, 1966; Holoien & Fiske, 2013; Wiggins, 1991), whereas other trait, life-span, and life-situation theorists view them as independent (Hassan & Bar-Yam, 1987; McAdams, 1985). In addition to these approaches, Leonard proposed a third model informed by group communication research that agency and communion relate interactively to mutually enhance one another. Another matter of debate involves the stability of agency and communion. Personality theorists emphasize the stability, whereas life span and developments emphasize the dynamic and experiential aspects of agency and communion (Eagly & Steffen, 1994; Peterson & Stewart, 1993; Richards & Larson, 1989).

Gender differences in agency and communion

Common to these frameworks are gender differences in agency and communion. Gender has intertwined with the constructs since their exposition, when Bakan (1966, p.110) posited that men are higher in agency and women higher in communion. This entanglement is also visible in that instruments used to measure masculinity and femininity largely use items of agency and communion (ACL: Gough & Heilbrun, 1965; BSRI: Bem, 1981; PAQ: Spence, Helmreich, & Stapp, 1975; see also Lippa, 2001). Since then many studies have partially corroborated the theorized gender differences. The relationship between agency and gender is inconsistent, since some studies show a male advantage (Costa, Terracciano, & McCrae, 2001; Diehl, Owen, & Youngblade, 2004; Feingold, 1994), while others do not (Eagly & Steffen, 1994; Twenge, 1997, 2001). The relationship between communion as gender is more consistent, with women being higher than men (Costa et al., 2001; Diehl et al., 2004; Eagly, 1987; Eisenberg & Lennon, 1983; Feingold, 1994).

Digit ratio and agency and communion

The present study hypothesized that since agency and communion relate to gender, they may also relate to digit ratio. Digit ratio, the ratio of the second to fourth finger, is a biomarker and negative correlate of prenatal testosterone exposure that stabilizes by the 14th week of gestation (Malas, Dogan, Evcil, & Desdicioglu, 2006; Manning, 2002; Manning, Scutt, Wilson, & Lewis-Jones, 1998). Prenatal testosterone stimulates the growth of the fourth finger, and is why the fourth digit (4D) in men tends to be longer than the second digit (2D, $2D:4D \leq 1$), but in women the digits tend to be the same length ($2D:4D \geq 1$, Manning et al., 2000). Prenatal testosterone has long-

lasting organizational influences on brain and behavior (Collaer & Hines, 1995), and there are several reasons supporting the putative relationship between digit ratio and agency and communion. Agency is implicated by findings relating testosterone, both prenatal and circulating, to extraversion (Lippa, 2006), assertiveness (Wilson, 1983), dominance (Grant & France, 2001; Manning & Fink, 2008), thing (non-social) occupational preferences (Lippa, 2006), and self-enablement (Fannin & Dabbs, 2003). Communion is implicated by findings relating testosterone, both prenatal and circulating, to social inhibition (Pennebaker, Groom, Loew, & Dabbs, 2004), empathy (van Honk et al., 2011), agreeableness (Fink, Manning, & Neave, 2004; Lippa, 2006), interest in child-care (Erhardt & Baker, 1974), and feminine-stereotyped behavior (Udry, 2000). These findings support the hypotheses that digit ratio negatively relates to agency, and positively relates to communion. The hypotheses necessarily produces the bi-polar model of agency and communion first theorized by Bakan (1966).

The hypothesis that agency and communion relate to digit ratio has been tested many times before, often by relating digit ratio to self-reports of sex-role identity using the BSRI or PAQ measures. Some studies have found positive relations between digit ratio and female sex-role identity (Beech & Mackintosh, 2005; Scarbrough & Johnston, 2005) and negative relations with male-sex role identity (Csatho et al., 2003; Rammsayer & Troche, 2007). However, Voracek, Pietschnig, Nader, and Steiger's (2011) meta-analysis of 28 studies found no systematic, robust, or noteworthy associations between digit ratio and masculine/feminine personality dimensions, since the only robust association was a positive, tiny association in men between left digit ratio and female sex-role identity.

The present study

Unlike the aforementioned sex-role studies which measure agency and communion using explicit self-reports (e.g., BSRI, PAQ), studies of agency and communion in self-narratives often use implicit measures. These self-narrative or diary studies typically operationalize agency and communion as word usage frequency or narrative theme; behaviors that are less consciously controllable. The usage of function words (e.g., pronouns, prepositions, articles, conjunctions, etc.) is particularly reflective of linguistic style since it is difficult to control (Chung & Pennebaker, 2007). Self-narratives are a key source for studying agency and communion since these dimensions have been shown to be thematic in self-narrative content (Mansfield & McAdams, 1996; McAdams, Hoffman, Mansfield, & Day, 1996). Another difference is that self-narrative studies, unlike the aforementioned sex-role studies, do not tend to focus on predictors of individual differences in agency and communion beyond gender (Diehl, Owen, & Youngblade, 2004; Lieblich, Zilber, & Tuval-Mashiach, 2008; McAdams et al., 1996). The present study seeks to bring together the methodological approaches of sex-role and self-narrative studies by being the first to relate implicit measures of agency and communion in self-narratives to individual differences in digit ratio.

There is some evidence why a putative association between digit ratio and agency and communion may be better revealed in implicit measures than explicit measures (e.g., BSRI, PAQ, see Voracek et al., 2011). Schmukle, Liesenfeld, Back, and Egloff (2007) argued that since implicit attitudes reflect traces of past experiences, early developmental events may influence implicit attitudes more than explicit attitudes. Guided by this reasoning, Schmukle et al. tested the relationship between digit ratio and explicit and

implicit self-concepts. They used the BSRI to measure explicit self-concept and the Implicit Association Test with images of “male” and “female” faces for the implicit self-concept. Their results confirmed their argument: for men digit ratio correlated stronger with implicit gender self-concept than explicit self-concept.

The present study is important because digit ratio may offer clues on the origins and nature of agency and communion, and their between- and within- gender differences. Digit ratio may lend differential support to the two broad frameworks accounting for gender differences in agency and communion. According to evolutionary theorists, gender differences in agency and communion are inherited traits that are adaptive solutions to the unique fitness landscapes that primeval men and women differentially faced (Buss & Kenrick, 1998; Hogan & Cheek, 1985). Sex role theorists, however, argue gender differences in agency and communion reflect experience in contemporary societal structure, namely the distribution of sex roles by gender, and not gender, per se (Eagly, 1987; Wood & Eagly, 2002). This latter framework is also consonant with developmental approaches that attribute gender differences to socialization, and situational influences (Hassan & Bar-Yam, 1987; Maccoby, 1990; Moskowitz, Suh, & Desaulniers, 1994).

METHOD

Participants

The sample consisted of 63 men and 78 women undergraduates attending Florida Atlantic University ($N=141$, $M_{\text{age}}=18.8$, $SD_{\text{age}} = 1.34$, age range=18-29). Participants were compensated with course credit. The study followed APA ethical guidelines and was approved by the university's IRB.

Procedure

Finger lengths were measured three times from hand scan images by trained research assistants using the ruler tool in Adobe Photoshop CS6, pursuant to the measurement guidelines by Voracek, Dressler, Manning (2007). Finger lengths were measured from the tip of the finger to the basal crease that divides the finger from the palm.

Data analysis

Self-narrative audio recordings.

Participants verbally described themselves after reading an open-ended prompt. The prompt asked participants to describe themselves as fully as possible, and suggested topics included personality, goals, and relationships; participants, however, were reminded of the open-format to speak freely as they chose. Participants spoke into a microphone in a private office for approximately 3 minutes.

Each self-narrative audio recording was transcribed by two research assistants blind to the purpose of the study. Differences in the two transcripts were reconciled by the assistants to reach a single agreed-upon transcript. The transcripts were then analyzed using the Linguistic Inquiry and Word Count 2007 text analysis software (LIWC; Pennebaker, Francis, & Booth, 2007). LIWC reports for a given text the frequencies of over 70 categories of content and function words according to its predefined internal dictionary. Words can fall into multiple categories, and many of the categories are hierarchical.

Agency and Communion in self-narratives using LIWC.

Ten LIWC categories were nominated for their prior application and relevance to the dimensions of agency and communion (Table 1). For example, in Holoiien and Fiske's (2013) study of impression management, agency was assessed using the LIWC categories *words longer than six letters*, *work*, and *achievement*, and communion by *social processes*, *friends*, *positive emotions*, *you*, and *question marks*. Agency and communion may also be implicated by the linguistic correlates of individuality and relatedness found by Burke and Dollinger (2005). They found the LIWC category *cognitive mechanisms* was positively related to individuality and negatively related to relatedness, whereas the category *social processes* demonstrated opposite relations. These categories also overlap with those chosen by Madera, Hebl, and Martin (2009) in a study of agency and communion in academic letters of recommendation. They used the LIWC categories *cognitive mechanism*, *motion*, and *achieve* to capture the insightful, active, dynamic, and achieving aspects of agency, and the category *social processes* to reflect the others-focus of communion. It should also be observed that *cognitive mechanism* is a superordinate

LIWC category that subsumes, amongst others, the category *exclusive*. *Exclusive* words separate, make distinctions, and differentiate (e.g., “but,” “without,” “exclude”; Tausczik & Pennebaker, 2010), and is arguably one of the closest predefined LIWC categories to the theoretical core of agency, which Bakan (1966) described most fundamentally as the modality of separation.

All of the categories discussed so far have been “content heavy,” meaning composed of nouns and regular verbs that define primary categories and actions (Chung & Pennebaker, 2007). However, agency and communion may also relate to several categories of “function” words. Function words occur frequently and form stylistic patterns of linking content words together. For example, communion is suggested by the social orientation implicit in the usage of *personal pronouns* (Chung and Pennebaker, 2007; Groom et al., 2003). Conversely, agency is suggested by the non-social, object, thing orientation implicit in the usage of *impersonal pronouns* (Tausczik & Pennebaker, 2010). Agency may also be related to the category *conjunctions* as these words are important for narrative coherence, and are associated with greater cognitive complexity (Chung & Pennebaker, 2007; Pennebaker & King, 1997; Tausczik & Pennebaker, 2010). Finally, Berry, Hiller, Mueller, and Pennebaker (1997) found that interviewees’ usage of *present tense* language was positively related to social judgments of both agency and communion. Taken together, these studies constituted the basis for selection of LIWC category variables for an exploratory factor analysis model of agency and communion.

Exploratory structural equation modeling.

Exploratory Structural Equation Modeling (ESEM) is a recent development in Structural Equation Models (SEM; Asparouhov & Muthen, 2009; Marsh et al., 2009; Marsh, Liem, Martin, Morin, & Nagengast, 2011). ESEM features all the typical SEM parameter estimates, standard errors, goodness-of-fit statistics, and statistical advances normally associated with CFA and SEMs. Unlike traditional SEM in which the measurement model is based on confirmatory factor analysis (CFA), ESEM bases the measurement model on exploratory factor analysis (EFA). This is beneficial because CFA specification of simple structure in the measurement model, which is typically achieved by fixing small-cross loadings to zero, can create small misspecifications that negatively impact the model. In other words, CFA's strong restrictions on cross-factor loadings may produce a model too parsimonious for the data, and result in inadequate goodness-of-fit indices. ESEM, which does not impose these restrictions on cross-factor-loadings, uses EFA with rotated factor loading matrices to discover the small complex cross-factor-loadings in the measurement model, and thereby avoids the issue of small misspecifications (Schmitt, 2011). This property makes ESEM useful to the present study because it allows flexible specification of the LIWC category cross-loadings on Agency and Communion factors, which may manifest a complex factor structure. This possibility is because, to the authors' knowledge, although LIWC categories have been used to assess agency and communion, they have never been factor analyzed for these dimensions. Additionally, complex factor structure may manifest because the relationship between agency and communion has been theorized in many contrasting ways: as independent, negatively related, or synergistic.

The first step in ESEM was to conduct an EFA to establish a valid measurement model of Agency and Communion factors from candidate LIWC categories. EFA was conducted in Mplus Version 7 to explore one through three factor solutions (Muthen & Muthen, 2012). Model comparison tests were conducted to compare the two-factor solution against other factor solutions. The factors were interpreted with respect to the LIWC category hypotheses and significance of factor loadings in the pattern matrix; LIWC items with nonsignificant factor loadings were removed. Model fit was evaluated using χ^2 tests and several fit indices (cutoff values for good fit based on Hu & Bentler, 1999; MacCallum, Browne, & Sugawara, 1996; Muthen & Muthen, 2009; Schmitt, 2011; Yu, 2002) including root mean squared error of approximation (RMSEA, $<.06$), comparative fit index (CFI, $>.95$), Tucker Lewis index (TLI $>.95$), standardized root mean square residual (SRMR $<.08$), Kaiser criterion (sample eigenvalue > 1), and parallel analysis (sample eigenvalues $>$ random data eigenvalues). Parallel analysis was conducted because it is the best empirical method for determining the number of factors to retain, and indicates the optimal number of factors by the number of sample eigenvalues larger than the parallel analysis random data eigenvalues (Schmitt, 2011).

After obtainment of the Agency and Communion factor model through EFA, ESEM was conducted in order to test the effects of predictors on the Agency and Communion factors. The three predictors were gender, digit ratio, and their interaction. Proper identification of the structural model required the imposition of four (m^2) constraints since the measurement model had two (m) factors (Muthen & Muthen, 2008). The four constraints were achieved by constraining the cross-loadings of two anchor items to zero, and constraining the two factor variances to one. The anchor items factor

loadings constrained to zero (i.e., items that strongly loaded on one factor but weakly loaded on the other factor) for the Agency and Communion factors were *personal pronouns* and *cognitive mechanisms*, respectively (see Table 2). Because maximum likelihood robust estimation was used model comparison tests used the Satorra-Bentler Scaled Chi-Square difference testing procedure (Satorra & Bentler, 1999).

Digit Ratio.

Inter-observer repeatabilities of finger-length measurements were assessed with one type of intraclass correlation coefficient (ICC), employing a two-way mixed-effects model with absolute-agreement definition (McGraw & Wong, 1996; Voracek, Dressler, & Manning, 2007). The three measurements for each finger-length were averaged before calculating right and left digit ratio. Since men's and women's digit ratio span different ranges, digit ratio was group mean centered prior to creating the interaction predictor of gender and digit ratio.

RESULTS

Repeatabilities of finger-length measurements

The inter-observer repeatabilities for the finger-length measurements were as follows (all $p < .001$, with $df_1 = 140$ and $df_2 = 280$ for the F ratio): ICC=.968 for right 2D ($F=145.189$), ICC=.962 for right 4D ($F=96.672$), ICC=.958 for left 2D ($F=73.351$), ICC=.932 for left 4D ($F=51.854$).

Sex differences in 2D:4D

Men's right digit ratio ($M=.947$, $SD=.028$) were significantly lower than women's digit ratio ($M=.965$, $SD=.028$), as commonly found; $t(139) = -3.648$, $p < .001$, and was of medium effect size ($d = -.64$). Men's left digit ratio ($M=.953$, $SD=.036$) were also significantly lower than women's digit ratio ($M=.967$, $SD=.030$), $t(139) = -2.468$, $p = .015$, and was of small effect size ($d = .42$).

LIWC Data

Since LIWC results include over 70 linguistic categories, summary data is presented only for those most relevant. Inspection of the transcripts validated their content as self-narratives, since all participants described themselves in compliance with the task ($N=141$, $M_{\text{word count}} = 277.28$, $S.D. = 110.01$). The means (standard deviations) for selected LIWC categories are the following: *achieve* 2.38 (1.33), *cognitive mechanisms* 17.32 (4.35), *conjunctions* 6.81 (2.54), *insight* 1.76 (1.22), *impersonal*

pronouns 4.99 (2.32), *personal pronouns* 12.18 (3.99), *present* 12.02 (3.71), *words longer than six letters* 17.81 (4.34), *social* 7.32 (2.98), *work* 3.96 (2.20). There were no gender differences in word count, but there were gender differences in the usage rates of the linguistic categories *achieve*, *personal pronouns*, *present tense*, *social*, and *words longer than six letters*. Men ($M = 2.74$, $S.D. = 1.47$) had higher rates of *achieve* words than women ($M = 2.11$, $S.D. = 1.14$), $t(139)=2.860$, $p=.005$, $d=.48$. Women ($M=13.53$, $S.D.=3.79$) had higher rates of *personal pronouns* than men ($M=10.50$, $S.D.=3.60$), $t(139)=-4.828$, $p<.001$, $d=.82$. Women ($M=12.94$, $S.D.=3.72$) had higher rates of *present tense* language than men ($M=10.89$, $S.D.=3.40$), $t(139)=-3.375$, $p=.001$, $d=.57$. Women ($M=8.11$, $S.D.= 3.08$) had higher rates of social usage than men ($M=6.34$, $S.D.=2.54$), $t(139)=-3.660$, $p<.001$, $d=.63$. Men ($M=18.65$, $S.D.=4.34$) had higher rates of *words longer than six letters* than women ($M=17.13$, $S.D.=4.23$), $t(139)=2.090$, $p=.038$, $d=.35$. There were no gender differences for the categories *conjunctions*, *cognitive mechanisms*, *impersonal pronouns*, *insight*, or *work*.

Exploratory Factor Analysis

Exploratory factor analysis with oblique Geomin rotation criterion and maximum likelihood estimation with robust standard errors was conducted in Mplus 7 using the ten variables hypothesized to load onto agency and communion dimensions (Muthen & Muthen, 2012). Geomin rotation criterion was selected because it outperforms other rotations for simple and moderately complex factor structures (Asparouhov & Muthen, 2008; Schmitt, 2011). The agency dimension was expected to have stronger loadings from *achieve*, *cognitive mechanisms*, *conjunctions*, *impersonal pronouns*, *insight*, *present tense*, *six letters*, and *work*. The communion dimension was expected to have stronger

loadings from *personal pronouns*, *social*, and *present tense*. Model fit was examined iteratively with the removal of one variable each time that failed to load significantly on either factor. This process removed *achieve*, *insight*, and *work*, and yielded a final two factor model with seven variables and good fit indices ($\chi^2 = 12.379$, $df = 8$, $p = .135$, RMSEA: .062, CFI: .983, TLI: .954, SRMR: .032, sample eigenvalue for two factors = 1.527, sample eigenvalue for two factors 1.527 > parallel analysis eigenvalues for two factors 1.201). Additionally, parallel analysis supported the two factor solution over a three factor solution because at three factors the parallel analysis random eigenvalues exceeded the sample eigenvalues (sample eigenvalue for three factors .847 < parallel analysis for three factors 1.078). The pattern of factor loadings was consistent with the hypotheses supporting their identification as Agency and Communion factors (Table 2). Additionally, chi-square difference testing using the Satorra-Bentler Scaled Chi-Square method showed the two factor model fit significantly better than the one factor model, $\chi^2(6, N=141) = 98.841$, $p < .001$ (Satorra & Bentler, 1999). The Agency and Communion factors were not correlated.

Exploratory Structural Equation Model

Exploratory structural equation modeling (ESEM) was used to examine the predictive effects of gender, digit ratio, and their interaction on the Agency and Communion factors. Four models were conducted each with Agency and Communion factors regressed on all three predictors, but the models differed on which regression paths were freely estimated. In Model 1 no predictors were freely estimated, since all three regression paths for gender, digit ratio, and their interaction were constrained to zero. In Model 2 one regression path for gender was freely estimated (unconstrained), but

the two regression paths for digit ratio and their interaction were constrained to zero. In Model 3 two regression paths for gender and digit ratio were freely estimated, but the third regression path for their interaction was constrained to zero. In Model 4 all three regression paths of gender, digit ratio, and their interaction were freely estimated (none constrained). This procedure of including all three predictors in the four models with the sequential freeing of (removal of constraints on) their regression paths fulfilled the criterion of nested modeling necessary for model comparison tests with different variables (Muthen, 2006). Nested modeling is demonstrated by the fact Models 1, 2, and 3 are each special (i.e., constrained) versions of the unconstrained general Model 4.

Model 2 (only gender freely estimated) had good fit indices ($\chi^2 = 39.627$, $df = 28$, $p = .07$, RMSEA: .054, CFI: .960, TLI: .940, SRMR: .046, Table 3). Gender significantly predicted the Warmth factor ($\beta = .38$, $p < .001$, $R^2 = .14$, $p = .008$, 95% CI [.04, .24]), but not the Agency factor. These results indicate that women had a significantly higher mean level for the Warmth factor in their self-narratives than men. Model comparison test showed the comparison Model 2 was a significantly better fit than the nested Model 1 with no predictors estimated (all predictor regression paths constrained to zero; $\chi^2 = 22.375$, $df = 2$, $p < .001$).

Next, both gender and digit ratio predictors were freely estimated in Model 3. Model 3 had acceptable fit indices ($\chi^2 = 38.180$, $df = 26$, $p = .058$, RMSEA: .058, CFI: .958, TLI: .932, SRMR: .048). Gender retained the same significant relationship to Warmth factor ($\beta = .38$, $p < .001$, $R^2 = .14$, $p = .008$, 95% CI [.04, .24]) and did not relate to the Agency factor as in Model 1. The interpretation of the significant gender effect is

the same as described for Model 2. Digit ratio was not related to Warmth and Agency factors. Model comparison test showed that the comparison Model 3 (gender and digit ratio predictors) was not a significantly better fit than the nested Model 2 (gender only predictor; $\chi^2 = 1.016$, $df = 2$, $p = .602$).

Next, all three predictors of gender, digit ratio, and their interaction were freely estimated in Model 4 (see Figure 1). Model 4 had very good fit indices ($\chi^2 = 29.873$, $df = 24$, $p = .189$, RMSEA: .042, CFI: .979, TLI: .963, SRMR: .041). Gender, digit ratio, and their interaction were significant predictors of the Warmth factor ($R^2 = .16$, $p = .005$, 95% CI [.05, .27]), but not the Agency factor. Gender retained the same significant relationship to the Warmth factor ($\beta = .38$, $p < .001$) as in the earlier Models 2 and 3, but not to the Agency factor. Digit ratio was significantly related to the Warmth factor ($\beta = .16$, $p = .037$), but not to the Agency factor. The interaction of gender and digit ratio also significantly related to the Warmth factor ($\beta = -.21$, $p = .011$), but not the Agency factor. Since an interaction was estimated in this model, the digit ratio regression coefficient is not a main effect, but rather represents the slope for men, the reference group (Jaccard & Turrisi, 2003, *p*.34). The significant digit ratio effect for men indicates that men exposed to lower levels of prenatal testosterone had higher Warmth factor scores in their self-narratives than men exposed to higher levels of prenatal testosterone. The significant interaction effect means that the relationship between digit ratio and the Warmth factor differed significantly by gender. When the model was rerun with reverse scoring women as the reference group instead of men, the interaction remained significant ($\beta = .21$, $p = .011$), but the digit ratio effect was no longer significantly related the Warmth factor.

Therefore, these results suggest that digit ratio significantly relates to Warmth factor levels in self-narratives for men, but not for women. Model comparison tests showed Model 4 (gender, digit ratio, and interaction) to be the best fitting model because it was a significantly better fit than Model 3 (gender and digit ratio; $\chi^2 = 15.007$, $df = 2$, $p < .001$), Model 2 (gender only; $\chi^2 = 12.628$, $df = 4$, $p = .013$), and Model 1 (no predictors; $\chi^2 = 40.421$, $df = 6$, $p < .001$). In summary, the results of Model 4 partially confirmed the hypotheses because the predictors gender, right digit ratio, and their interaction significantly related to the Communion factor, but not the Agency factor (Table 4).

DISCUSSION

The present study hypothesized its results would support one theoretical framework over the other in regards to the origins and nature of agency and communion. Contrary to the expectation, the results were consistent with both evolutionary and socialization accounts. Evolutionary theorists tend to frame individual differences in agency and communion as inherited, distally influenced by biological factors, and stable (Buss & Kenrick, 1998; Hogan & Cheek, 1985). The present study's finding that digit ratio positively related to communion in men directly supports the evolutionary framework, because it shows the influence prenatal hormonal factors exert on communion. Additionally, this finding resonates with the position held by evolutionary accounts that stable individual differences have distal temporal (i.e., inherited) causes because digit ratio permanently stabilizes by the 14th week of pregnancy (Malas et al., 2006), remains fixed across the lifespan, and is substantially heritable (Voracek & Dressler, 2007). On the other hand, the null result that digit ratio did not relate to agency indirectly supports alternative socialization accounts that (i.e., does not contradict) agency develops with experience and is affected by social structure (Eagly & Wood, 1999; Hassan & Bar-Yam, 1987; Moskowitz et al. 1994).

The gender difference found for communion but not agency, and the relative view of agency and communion suggested by the results, that whereas communion is stable

and fixed, agency is dynamic and situational, parallels findings from other studies. Twenge's (1997) meta-analysis on BSRI and PAQ scores collected across twenty years of studies found a time effect of agency increasing over time for men and women, but to the point there were no longer gender differences. Similarly, Abele's (2003) test of a reciprocal impact model found a bidirectional influence between agency and career success but not for communion and family role experience. Moskowitz et al. (1994) found agency, but not communion, fluctuates with social status and social role expectations, and that women were more communal than men regardless of status.

The present finding of an association between digit ratio and communion supports the distal, inherited influences posited by evolutionary accounts, but only partially supports views of communion as stable. Although the finding may seem to corroborate communion's stability, this is not necessarily so for two reasons. The first reason is because communion exhibits dynamism, and is not as static as some studies suggest. Brown and Moskowitz (1999) using spectral analysis on event-sampled data found both agency and communion exhibit rhythmic fluctuations across days of the week, and that communion had comparable levels of fluctuation as agency. The second reason is because prenatal hormonal exposure, as indexed by digit ratio, does not have a fixed static effect, but rather influences behavior across distal and immediate time scales. The distal influence is due to the putative early and permanent organizing effect prenatal testosterone exposure has on the brain (Collaer & Hines, 1995; Phoenix, Goy, Gerall, and Young, 1959). A consequence of this distal organizing effect, which leads to the immediate influence, is prenatal testosterone exposure alters neural substrates responsiveness to activational effects of circulating (e.g., daily) testosterone. The

relevance of these multiple dynamic influences is that communion may fluctuate not only with digit ratio as found, but also with the interaction of digit ratio and circulating testosterone. Substantiating this hypothesis is a study by Pennebaker et al. (2004), who found increases in circulating testosterone led to decreases in communion. Similarly, Van Honk et al. (2011) found performance on a cognitive empathy test, a communion-like behavior, was predicted by the interaction of digit ratio with circulating testosterone.

Still, important questions remain such as why or how digit ratio relates to communion. The first clue lies in Digman's (1997) interpretation of the superfactor α . Because α underlay the correlations among the three personality factors of Agreeableness, Conscientiousness, and Emotional Stability, factors dealing with impulse restraint, conscience, and the reduction of hostility, he suggested α represents socialization itself, and "is what personality development is all about" (Digman, 1997, p.1250). According to this interpretation, communion represents the degrees of success achieved by the socialization process. Bakan viewed communion similarly, stating because females are higher in communion "males and females are differentially affected by culture" (Bakan, 1966, p.117). The second clue comes from a study by Udry (2000) which linked degree of socialization success to prenatal testosterone exposure. Udry measured women's feminine behaviors, and the extent to which during childhood their mothers encouraged femininity. Because the study begun decades earlier and prenatal blood samples were collected from the participants' mothers, participant exposure level to prenatal androgens was known. The results of the study revealed an interaction between prenatal androgen exposure and degree of socialization success. That is, for women with low exposure to prenatal androgen exposure (i.e., high digit ratio), mother's

encouragement of femininity had a strong effect on gendered behavior in adulthood. By contrast, for women with high exposure to androgen (i.e., low digit ratio), mother's encouragement had little effect on adult gendered behavior. Together, these studies suggest the present relationship between digit ratio and communion (usage of social words) in self-narratives may reflect the broader relationship between digit ratio and communion, as the degree of success of socialization itself.

Agency and communion are fundamental dimensions of many psychological processes. This study sought to better understand their origin and nature by testing whether within- and between-gender differences in agency and communion relate to digit ratio. To this purpose, Agency and Communion factors were extracted from implicit linguistic measures obtained by LIWC analysis of self-narratives. The results of exploratory structural equation modeling found communion related to digit ratio in men, and gender differences in communion. Although the results supported the distal, biological influences of communion argued by evolutionary accounts, it is well known behavior results from the interaction of prenatal androgens and socialization. The null finding agency was not related to digit ratio, while not directly interpretable, did not contradict socialization accounts of agency. One caveat concerns an inherent limitation of the study design. LIWC analysis is a powerful approach to quantifying agency and communion in self-narratives, but it is also a simple approach susceptible to missing a text's broader meanings, as compared to, for example, McAdams' (2001) qualitative autobiographical coding system for agency and communion themes. Another issue is that agency is a more multifaceted construct than communion, and may not have been as covered by its LIWC categories. The Agency factor reasonably captured the competence

and intelligence aspects of agency, but perhaps McAdams' thematic coding system could better identify its other aspects of self-mastery, self-actualization, and dominance. Finally, it remains unknown whether these findings pertain to actual behavior beyond self-perceptions or self-presentations of communion. These caveats acknowledged, agency and communion are dramatic features appearing across the lifespan in matters of the development of a mature self (Guisinger & Blatt, 1994), the obtainment of positive health outcomes (Helgeson, 1994; Blackburn, Logan, Renwick, & Donnelly, 2005), and in generativity (Mansfield & McAdams, 1996). Apparently, communion is born even before its nascent actor.

Table 1

LIWC categories used for exploratory factor analysis of agency and communion dimensions. The “+”, “-,” “0”, and “/” respectively indicate hypothesized positive, negative, zero loading, and no hypothesized relation was made.

LIWC category	Example words	Hypothesized relations to agency dimension	Hypothesized relations to communion dimension	Hypothesized stronger loading dimension; previous usage and relevance
<i>Achieve</i>	Earn, hero, win, ability, fulfill, plan, gain	+	0	Agency; (Holoien & Fiske, 2013)
<i>Cognitive mechanisms</i>	Cause, know, ought, affect, idea, if, purpose	+	-	Agency; (Burke & Dollinger, 2005)
<i>Conjunctions</i>	And, but, whereas, also, although, otherwise, so, then	+	/	Agency; (Chung & Pennebaker, 2007; Pennebaker & King, 1997)
<i>Impersonal pronouns</i>	It, it’s, those, anything, other, that, thing, whatever	+	-	Agency; (Tausczik, Pennebaker, 2010)
<i>Insight</i>	think, know consider, decide, examine, inform	+	0	Agency (Burke & Dollinger, 2005; Tausczik & Pennebaker, 2010)
<i>Personal pronouns</i>	I, them, her, we, you, they, he, ours	/	+	Communion; (Chung & Pennebaker, 2007)
<i>Present tense</i>	is, does, hear	+	+	Agency/Communion; (Berry, et al., 1997)
<i>Six letters</i>	Words longer than six letters	+	/	Agency; (Holoien & Fiske, 2013)
<i>Social</i>	Mate, talk, they, child, friends, family, humans	-	+	Communion; (Burke & Dollinger, 2005; Holoien & Fiske, 2013)
<i>Work</i>	Job, majors, busy, homework, motivation	+	0	Agency; (Holoien & Fiske, 2013)

Table 2

Factor Loadings for Exploratory Factor Analysis With Geomin Rotation of LIWC

Categories.

LIWC Category	Agency dimension	Communion dimension
Cognitive mechanisms	.875*	.046
Conjunctions	.551*	-.214*
Impersonal pronouns	.528*	-.022
Personal pronouns	-.102*	.969*
Present	.244*	.612*
Six letters	-.194*	-.646*
Social	.366*	.292*

Note. * $p < .05$.

Table 3

Summary of fit indices for exploratory structural equation models

Model	χ^2	df	RMSEA	CFI	TLI	SRMR
Model 1	62.081***	30	.087	.889	.845	.084
Model 2	39.627	28	.054	.960	.940	.046
Model 3	38.180	26	.058	.958	.932	.048
Model 4	29.873	24	.042	.979	.963	.041

Note: χ^2 = Maximum likelihood robust; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker–Lewis index; SRMR = standardized root mean square residual.
N = 141: *** $p < .001$.

Table 4

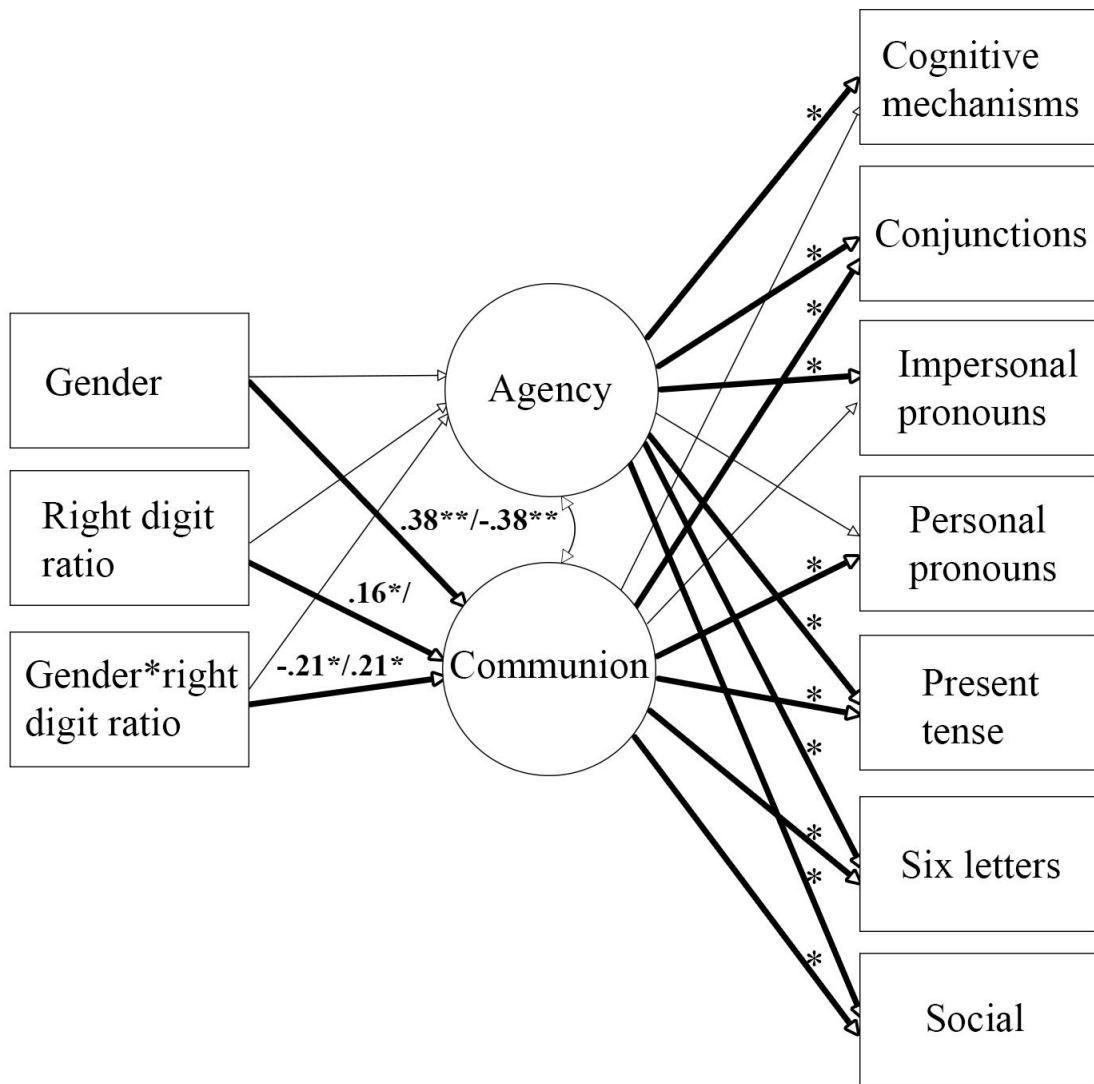
Predictors of Agency and Communion factors from Model 4

Factor (% variance explained)	Predictors and significant factor effects on each factor	β	S.E.	p
Agency (5.5%)	Gender – reference group men	.172	.093	.063
	Right digit ratio	.236	.134	.077
	GenderXdigitratio	-.189	.127	.139
Communion (16%*)	Gender – reference group men	.376	.071	<.001
	Right digit ratio	.159	.077	.037
	GenderXdigitratio	-.209	.082	.011

Note:

$N = 141$; * $p = .005$. S.E. = Standard error.

Figure 1. Exploratory structural equation Model 4 of Agency and Communion factors regressed on all freely estimated predictor variables. Significant paths are in bold.



Note. $*p < .05$. $**p < .001$. Reference group men/reference group women standardized regression coefficients.

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