**Discussion**

Surprisingly, our meta-analysis failed to find significant sex differences in either trait means or trait variability for personality-like behaviours. When personalities were divided into their respective trait type (the Big Five) we found several significant sex differences in means for some personality types within some taxonomic groups (birds: Sociality; reptilia: Exploration; invertebrates: Aggression, Boldness). However, only exploratory behaviour for birds and aggressive behaviour for fish had significant sex differences in variability, both skewing towards females. Finally, personality and SSD interacted significantly to show strong sex-bias for mean personality, yet only within mammals (male-bias for all personality types except activity, which had a female-bias) and fish (female-biased aggression), and did not moderate sex differences in variability for any personality type or taxonomic group.

Despite suggestions that greater male variability should exist for most shared traits (e.g. Reinhold & Engqvist 2013), the scarcity of male-biased sex differences found by our meta-analysis hints that greater male variability might be true only for traits important for reproduction. First, we found almost no male-bias in either trait means or variability for behavioural types where we expected strong male-bias (e.g. aggression). This result was surprising given that male aggression should correlate with male-male competition and reproduction (reference). In contrast, human antisocial personality types (equivalent to aggression in animals) show greater male than female variability (references). Aggressive personality traits in humans are thought to be maintained by negative frequency-dependant selection whereby it’s beneficial for male reproductive success to have fewer extremely aggressive males in the population (references). Second, our chosen sexual selection moderators (SSD and mating system) did not significantly change either mean trait expression or variability; while SSD did interact with personality trait type for mean trait expression in mammals, SSD had no significant effect on variability for any taxonomic group. As such, it’s unlikely that sexual selection plays a major role in the maintenance of personality-like behaviours in animals.

* So what about human personality? A lot of personality axes with strong male bias are thought to be maintained by negative frequency dependant selection and to be important for reproduction. Other personality traits often have no difference in means or variability between males and females
* Archer and Mehdikhani (2003) talk about and compare means and variances between males and females for personality-like traits related to sexual selection and unrelated to sexual selection. They found that traits related to sexual selection (directly like physical aggression, or indirectly through a change in reproductive strategy) consistently had significant greater male variability, while traits unrelated to sexual selection had no difference in variability, but often greater female means. *Good paper to relate my main finding that, depending on the context under which a personality trait is measured, there’s likely to be no sex differences in variability! Especially where a trait is related to survival…*

For non-sexual shared traits, the sex chromosome hypothesis suggests that trait variability should reflect sex chromosomal arrangement. While we did observe a tendency for mean variability estimates to skew towards the heterogametic sex (especially mammals and birds), most estimates were nonsignificant. Again, this result was surprising considering the number of studies that report underlying sex chromosomal arrangement as the mechanism for greater male trait variability. Greater male than female variability has been reported for traits like personality types in humans (Budaev 1999, Archer & Mehdikhani 2003, Karwowski *et al*. 2016), cognition and intelligence (Halpern & LaMay 2000, Jones *et al.* 2003, Arden & Plomin 2006, Johnson *et al.* 2008, 2009), and for morphological traits like body size (Reinhold & Engqvist 2013), and brain structure (Arnold 2004, Van der Linden *et al*. 2017, DeCasien *et al*. 2020). Importantly, these traits are also considered important for reproduction; in men, extraversion and creative personality types attract more mating opportunities (Buss 1995, Nettle 2006), while body size is a condition-dependent trait important for male-male competition for females (refs). Therefore, we should expect traits related to reproduction to have greater male variability, and not because of sex chromosomal arrangement. Since we did not observe significant sex differences in variability following sex chromosomal arrangement, animal personalities could encompass behaviours that don’t differentially affect reproductive outcomes for the heterogametic sex. *Garbage*

* Can also mention greater female variability in some traits, like vision (both mice and humans) which might indicate some traits are more beneficial for females to express variation (finding food, seeing predators?) (see Shaqiri *et al*. 2018, and also Suzie’s paper)
* We might see greater male variability in morphological traits, like body size, brain structure and in traits directly related to morphology, like intelligence or cognition (see that chimp paper), but we don’t see such sex differences in behavioural traits ??? This could be explained by behaviours having a complex genetic underpinning (controlled by multiple genes that aren’t sex-linked?) or that personality-like behaviours are important for survival in both sexes so there is no sexual conflict ??? Something like this I guess
* Wyman and Rowe (2014) conducted a meta-analysis comparing heritabilities and additive genetic variances of phenotypic traits for males and females. When using a t-test, they found that mean male coefficients of variance were not significantly different from mean female coefficients of variance for non-reproduction-related phenotypic traits, as well as traits important for reproduction. – *this is most similar to my results and more comparable to lnCVR*
  + But there was a significant skew towards male-bias for coefficients of phenotypic variance for reproductive traits, non-reproductive traits, and the entire dataset.
  + Reproduction traits showed more male-biased phenotypic variance than not-reproduction related traits

An alternative explanation for both sexes sharing similar means and variances for personality traits could be that both sexes experience similar trade-offs between personality and survival. In a meta-analysis examining the fitness consequences of personality, Smith & Blumstein (2008) found that bolder individuals, particularly males, had increased reproductive success but also incurred a survival cost. However, a more recent meta-analysis found no evidence that bolder individuals suffered higher mortality rates, but did find that personality types explained some variance in survival (Moiron *et al*. 2020). The behaviours most biologists measure as personalities often encompass antipredator responses (‘risky’ behaviour, or Boldness), foraging (Activity/Exploration), and other behaviours related to survival. And because there are costs (in terms of energetic investment) and benefits (e.g. faster growth, more feeding opportunities) associated with such behaviours, it seems intuitive that both sexes should express similar trait means and variabilities. The results of our meta-analysis support this idea in two ways; first, we found strong interactions between SSD and personality trait types for mammals, where males are strongly dimorphic, which could relate to Rensch’s rule - in species where males are bigger than females, the size differences between the sexes increases with body size. Indeed, we have several large mammalian species in our dataset with big differences in body sizes. Additionally, as male size increases, female size increases as a result of fecundity and viability selection, so it’s possible that, for mammals at least, using SSD as a proxy for sexual selection actually encompasses 3 different types of selection that might also operate on personality traits… like females and activity (big females need to be more active to get enough food to fuel their big bodies and subsequent offspring), males and aggression (bigger males are often the dominant individual so bigger means more testosterone

* Maybe talk about life-histories in here

1. Personality traits, in animals, are often scored around the lowest and highest expression of those traits (i.e. antisocial vs extraverted, docile vs aggressive, shy vs bold, inactive vs active, safe vs explorative). It’s possible that the means for males and females are some average of the two extremes that doesn’t represent the true mean and variation of the population
2. Assortative mating? Maybe males and females prefer to mate with a similar personality so the variation between the sexes remains the same? Not good wording but something to that effect (mate choice and personality review would fit here)
3. Antipredator or behaviours related to survival (like exploration) experience much stronger selection than other personality traits (where there is no optima), which would explain the strong interaction with sexual size dimorphism. Also how mating might change personalities in females and males differently? (fish paper from 2020)
4. Or variability in personality could be a bet-hedging strategy for both sexes so it would make sense for them to have variability and somewhat lower heritability … might also explain the lack of sex differences in the means of traits because there is no single optimal personality mean

* Finally, we see strong interactions between SSD and personalities for mammals only, where males are strongly dimorphic, which could relate to Rensch’s rule - in species where males are bigger than females, the size differences between the sexes increases with body size. Indeed, we have several large mammalian species in our dataset with big differences in body sizes. Additionally, as male size increases, female size increases as a result of fecundity and viability selection, so it’s possible that, for mammals at least, using SSD as a proxy for sexual selection actually encompasses 3 different types of selection that might also operate on personality traits… like females and activity (big females need to be more active to get enough food to fuel their big bodies and subsequent offspring), males and aggression (bigger males are often the dominant individual so bigger means more testosterone
* Those few meta-analyses that talk about personality and fitness/survival

*Final paragraph – what’s missing, bias, what’s next?*

* Need a nice sentence here to wrap everything up and summarise our meta-analysis!
* Potential source of bias in our meta-analysis – most species where sex differences in personality have been recorded are quite sexually dimorphic. Would be interesting to see more species where males and females are monomorphic to see how general our findings are.
* Greater variability in wild populations?
* The results of our meta-analysis might offer important insight into the mechanisms underpinning shared behavioural trait expression.
* For our significant measures of phylogeny on heterogeneity (I2) for lnCVR in birds and mammals, we can say that this suggests heritability of personality in these groups – heritability measures the degree of phenotypic variation due to genetic (not environmental) variation. This would suggest that variability in personality traits, for birds and mammals, are not driven by environmental conditions but are instead heritable. As such, any sex differences in variability in personalities would be due to heritable variation