**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.

*Paragraphs 2 & 3– why no sex differences? No sexual selection, sex chromosomal hypothesis is likely not as general as previously thought…*

Despite suggestions that greater male variability should exist for most shared traits (e.g. Reinhold & Engqvist 2013), the scarcity of male-biased sex differences in our meta-analysis hints that greater male variability might only be true for traits important for reproduction. First, behavioural types where we expected strong male-bias within each taxonomic group, like aggression, showed no male-bias in either trait means (except for invertebrates) or variability. This result was surprising given that male aggression correlates with male-male competition (reference). In contrast, human antisocial personality types (equivalent to aggression in animals) show greater male than female variability. 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
* So what’s going on? Could be assortative mating? Could be traits are important for survival for both sexes … e.g. most tests used to measure personality measure behaviours important for antipredator or foraging … reference those fitness meta-As … interaction with SSD supports this pretty well too

What about the sex chromosomal hypothesis? Unlike Reinhold and Engqvist general suggestion that trait variability should reflect sex chromosomal arrangement, it’s not really the case for animal personality traits… more applicable to morphology or physiology (examples) than behaviour… but why?

* See differences in variability for traits like body size (Reinhold & Engqvist 2013), brain size (chimps and humans) that relate to the sex chromosome hypothesis… also cognition, which is probably due to differences in brain morphology related to sexual selection … susie’s paper about visual differences in mice etc which kind of makes the point that sex differences are related to reproduction or life history differences …

1. Personality traits might not be important for sexual selection in the species represented in our meta-A
2. 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
3. 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)
4. 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)

BASICALLY:

* We don’t see differences in means or variability in personalities between the sexes, which means that personalities are unlikely to be under sexual selection (in our sample of species), or that personalities are equally variable in the sexes because they are heritable, and trade-off with life-history traits important for survival
* 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
* 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…*
* 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
* Those few meta-analyses that talk about personality and fitness/survival

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

* 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

*Paragraph 4 & 5 – SSD and significant sex differences, life histories and sex-bias in means, assortative mating and other reasons for no differences…*

* Sexual size dimorphism alone doesn’t moderate sex differences in personalities, which suggests that the greater male variability hypothesis, nor the sex chromosome hypothesis don't apply to animal personalities
  + More relevant for morphological traits than behavioural according to the literature
* 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
* 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)
* There was a non significant tendency for the heterogametic sex to have greater variation for most personality traits within the five broad taxonomic groups. It’s possible that we would see stronger sex differences in wild populations where variation in traits should be stronger, however we lacked the power to test this assumption.

*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.