Sex/gender differences in verbal fluency and verbal episodic memory – a meta-analysis

Journal:	*Perspectives on Psychological Science*
Manuscript ID	PPS-19-077.R2
Manuscript Type:	Original Article
Date Submitted by the Author:	10-Jan-2022
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Keywords:	Action / Performance, Individual Differences, Sex / Gender, Methodology: Behavioral, Language / Communication, Cognition
User Defined Keywords:	cognitive gender differences, age, verbal ability, author effects

Abstract

Women are thought to fare better in verbal abilities, especially in verbal fluency and verbal memory tasks. However, the last meta-analysis on sex/gender differences in *verbal fluency* dates from 1988. While *verbal memory* has only recently been investigated meta-analytically, a comprehensive meta-analysis is lacking that focuses on verbal memory as it is typically assessed, for example, in neuropsychological settings. Based on 496 effect sizes and 355,173 participants, the current meta-analysis found that women/girls outperformed men/boys in phonemic fluency ($d = 0.12$-0.13) but not in semantic fluency ($d = 0.01$-0.02), where the sex/gender difference appeared to be category-depended. Women/girls also outperformed men/boys in recall ($d = 0.28$) and recognition ($d = 0.12$-0.17). Although effect sizes are small, the female advantage was relatively stable over the past 50 years and across lifetime. Published articles reported stronger female advantages than unpublished studies and first authors reported better performance for members of their own sex/gender. We conclude that a small female advantage in phonemic fluency, recall, and recognition exists and is partly subject to publication bias. Considerable variance suggests further contributing factors, such as participants' language and country/region.

Key words: verbal ability, gender, cognitive gender differences, verbal memory, age, author effects

Public significance statement: This meta-analysis showed that girls and women outperform boys and men in verbal episodic memory and phonemic fluency (e.g., generating words that start with a certain letter). The female advantage was smaller than previously thought, but still has important implications, for example, when verbal fluency and memory tasks are used in psychological assessment.

Sex/Gender Differences in Verbal Fluency and Verbal Episodic Memory. A Meta-analysis

After more than 100 years of psychological research, sex/gender[1] differences in cognitive abilities are still heavily debated (for review Halpern, 2012; Hyde, 2014). Spatial and mathematical abilities, in which men are commonly believed to excel, are very well researched. For instance, a male advantage in mental rotation, the ability to rotate complex figures in one's mind, has been reported in several meta-analyses with effect sizes around Cohen's d = 0.56-0.73 (Linn & Petersen, 1985; Voyer et al., 1995; Zell et al., 2015). By comparison, much less is known about verbal abilities, in which women/girls are commonly believed to excel. There is no unitary concept of verbal abilities but it relates to all aspects of open or inner language production and comprehension. Meta-analyses reported female advantages with medium effect sizes for writing ability, d = 0.53 to 0.61 (Hedges & Nowell, 1995), and reading comprehension, d = 0.23 to 0.68 (Reilly, 2012; Stoet & Geary, 2013). Verbal intelligence/reasoning (Feingold, 1988) and vocabulary (Hyde & Linn, 1988), on the other hand, did not reveal a female advantage with effect sizes smaller than d = 0.05 (Hyde, 2005, 2014).

The two verbal abilities, however, that textbooks and review articles typically refer to when claiming the existence of a female advantage are *verbal fluency* (sometimes also called "word fluency") and *verbal memory* (Andreano & Cahill, 2009; Halpern, 2012; Hamson et al., 2016; Hyde, 2014; Kimura, 2000; Miller & Halpern, 2014). Verbal fluency and verbal memory tests correlate with general cognitive abilities (Alexander & Smales, 1997; Kraan et al., 2013) and are frequently used in psychological assessments of developmental impairments in children

[1] Cognitive differences between men/boys and women/girls arise from a complex interplay of biological, psychological, *and* socio-cultural factors. These factors would be so intertwined that it would not be logical to distinguish between biology ('sex') and social environment ('gender'). In the current study, we therefore aimed for a neutral terminology, avoiding 'sex' or 'gender' as separate terms and instead using 'sex/gender' whenever possible. In certain contexts, however, it would be inappropriate to use "sex/gender" when addressing specific biological or social constructs, such as 'gender equality', 'gender stereotypes', 'sex hormones' or 'sex chromosomes'. When addressing first/last author effects, we refer to gender, because we identified authors as males or females simply based on their first name, not knowing their biological sex or gender identity.

(Gaillard et al., 2003; Pennington & Ozonoff, 1996), impairments and rehabilitation after stroke (Baldo et al., 2006; Barker-Collo & Feigin, 2006), and cognitive decline in dementia (Collie & Maruff, 2000; Zhao et al., 2013).

Verbal Fluency

Verbal Fluency refers to the ability to generate (orally or written) as many words as possible that fulfil a certain criterion, normally under time restrictions. The criterion is typically either *semantic*, also called "categorical fluency" (e.g., naming animals, fruits, etc.) or *phonemic* (e.g., naming words that begin with a specific letter), also called "lexical/letter fluency". Virtually all articles that claim women's/girls' superiority in verbal fluency refer to a landmark meta-analysis by Hyde and Linn (1988), who examined sex/gender differences in a few verbal abilities. The authors concluded that "speech production" or "verbal production" favored women by $d = 0.33$. However, the definition of "speech production" ("as occurs in essay writing or measures of spoken language", p. 55) is different from the verbal fluency definition above and, consequently, some studies in Hyde and Linn (1988) assessed different verbal abilities, such as quality of essays or written sentences (Harris & Seibel, 1976; Wormack, 1979) or how many words four-year-old children speak (Brownell & Smith, 1973). Moreover, the meta-analysis was based on only 14 studies, while the Web of Knowledge revealed that ~7500 references included the term "verbal fluency" since 1988.

Phonemic versus Semantic Fluency, Age, Cohort Effects, and Gender of First/Last Author

Heister (1982) found a female advantage when participants were asked to generate words beginning with the letters 'S' and 'M' (phonemic fluency), while no sex/gender differences emerged for naming things that are 'red' or 'round' (semantic fluency). Other studies reported a female advantage in semantic fluency (Acevedo et al., 2000) or did not find a sex/gender difference in either phonemic or semantic fluency (Kavé, 2005). Overall, it is unclear whether a female advantage exists in both semantic and phonemic fluency.

Furthermore, it is unclear at what age the putative female advantage arises and whether it changes across the lifespan. Some studies suggest a steeper decline in older men as compared to women (Maylor et al., 2007; Rodriguez-Aranda & Martinussen, 2006), while de Frias et al. (2006) found that the female advantage in semantic fluency was stable between 35 and 80 years. Based on semantic fluency data from more than 30,000 individuals (aged 50 to 84 years) in fourteen European countries, Weber et al. (2017; 2014) showed that women from younger cohorts performed better than women from older cohorts. Sex/gender differences also varied across European countries. Both findings were interpreted to show the impact of better access of women to resources and education (Weber et al., 2017; 2014). So far, it is unclear whether sex/gender differences in verbal fluency change with age or across cohorts.

Finally, Hyde and Linn (1988) found that female first authors reported a stronger female advantage (d = 0.15) than male first authors (d = 0.08). However, this finding was based on all verbal abilities and, though statistically significant, the difference was considered to be unsubstantial. The current study sought to replicate the findings by Hyde and Linn (1988) but more specifically with respect to verbal fluency. In addition, we also investigated the influence of gender of the last author, who is often the supervisor or more senior researcher overseeing the research effort.

Verbal Episodic Memory

As with verbal ability, there is no unitary definition of verbal memory. Nevertheless, there is a multitude of empirical data on what researchers considered verbal memory. Several studies found better performance in women (Catani et al., 2007; de Frias et al., 2006; Herlitz et al., 1997; Lowe et al., 2003) and a narrative review concluded that “females show an advantage at verbal memory” (Andreano & Cahill, 2009, p. 260). However, other studies found no sex/gender differences in verbal memory (Munnelly, 2016; Parsons et al., 2005). Meta-analyses on this issue were lacking until recently. Voyer et al. (2021) focused specifically on verbal *working* memory and found an overall significant female advantage that, however, was practically zero (*Hedge's* $g = 0.03$). Furthermore, sex/gender differences varied across different sample and task parameters: tasks with cued recall ($g = 0.08$) and free recall ($g = 0.15$) had a slightly elevated female advantage while there was a male advantage in complex span ($g = 0.04$) and no significant sex/gender difference in serial recall ($g < 0.01$) and simple span ($g < 0.01$).

Another meta-analysis (Asperholm et al., 2019) investigated sex/gender differences in long-term memory, specifically episodic memory. Long-term memory is typically divided into declarative (explicit) and non-declarative (implicit) memory, where declarative memory comprises episodic memory (i.e., the ability to remember specific events or situations at a particular place at a particular time) and semantic memory (i.e., the ability to remember concepts and facts). Asperholm et al. (2019) investigated sex/gender differences in episodic memory for different stimuli, including images, movies, faces, routes, locations but also verbal content such as words/sentences. Verbal content showed a small female advantage ($g = 0.28$). A wide range of studies/tasks were included in the verbal episodic category and the authors investigated whether the female advantage varied across, for example, neutral stimuli versus emotional stimuli, intentionally learnt versus incidentally learnt, or recall versus recognition. Subsequent analyses of moderator variables such as age, publication year, or geographical region took into account whether the stimulus material was verbal, images, movies, or faces, but did not distinguish between incidental/intentional, emotional/neutral, or recall/recognition, and only peer-reviewed articles were included.

Like Asperholm et al. (2019), the present study was interested in episodic long-term memory and thus discarded studies/tasks that primarily assess working memory. In contrast to Asperholm et al. (2019), the current study had a narrower focus on verbal episodic memory, which we investigated with a broader literature search. That is, we examined exclusively *verbal* episodic memory (not memory for routes and locations) and only included studies with neutral stimuli (as opposed to emotional stimuli), in which participants learnt material intentionally (as opposed to incidentally). The intentional learning of neutral stimuli is a key feature of frequently used neuropsychological tests on verbal long-term memory, such as the California Verbal Learning Test (CVLT; Delis et al., 2000), the Rey Auditory Verbal Learning Test (RAVLT; Schmidt, 1996), or the Wechsler Memory Scale (WMS; (Wechsler, 2009). Further in contrast to Asperholm et al. (2019), the literature search of the current study also comprised 'gray' literature such as PhD/Master's theses to investigate whether sex/gender differences are subject to publication effects. Moreover, the current study examined, for the first time, possible effects of first/last authors' gender on sex/gender differences in verbal episodic memory. Finally, we performed these analyses separately for *recognition* (i.e., when cues are provided for the material that had to be memorized) and *recall* (i.e., absence or lack of cues), because the female advantage appeared to be consistently larger for recall than for recognition (Asperholm et al., 2019; Voyer et al., 2021). The fact that only 14 and 18 of our 168 included studies overlapped with Voyer et al. (2021) and Asperholm et al. (2019), respectively, demonstrates that different aspects of verbal memory were investigated in the current study. Henceforth, we thus used the term "verbal episodic memory" when referring to the data that were analyzed in the present study, and "verbal memory" when referring to verbal memory in general.

Aims and Hypotheses

A female advantage is frequently assumed in verbal fluency and verbal memory. For *verbal fluency,* this assumption is based on an early meta-analysis by Hyde and Linn (1988) that required an update. For *verbal memory*, a meta-analysis was missing that focuses specifically on *verbal* episodic memory – complementary to two recent meta-analyses about verbal working memory (Voyer et al., 2021) and episodic memory in general (Asperholm et al., 2019). The present study thus aimed to reveal the magnitude of the putative female advantage in verbal fluency and verbal episodic memory. For both, we additionally examined the impact of potentially modulating factors such as publication year, type of publication (articles versus PhD/Master theses), participants' age, semantic fluency versus phonemic fluency, recall versus recognition, and gender of first/last author. We hypothesized a female advantage (i) in both verbal fluency and verbal episodic memory of intentionally learnt neutral stimuli (Andreano & Cahill, 2009; Halpern, 2012; Miller & Halpern, 2014), (ii) that has increased over the past 50 to 60 years due to better access to education for women (Weber et al., 2017; Weber et al., 2014), (iii) which emerges across all age groups but becomes larger in older adults (Maylor et al., 2007; Rodriguez-Aranda & Martinussen, 2006), and (iv) is affected by the gender of the first (Hyde & Linn, 1988) and last author.

Methods

The meta-analysis including literature search, study selection, data analysis, and presentation of results was performed following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009) and the recommendations for meta-analyses described by Borenstein et al. (2009). Data analysis was carried out with Comprehensive Meta-Analysis (CMA) version 3.3.070 (Borenstein et al., 2014).

Literature Search and Study Selection

Search Terms and Databases

Between 22nd to 29th October 2016, the databases PsychInfo, ISI Web of Knowledge, and PubMed were searched for relevant literature. Between 13th and 19th September 2019, we additionally searched the "ProQuest Dissertation & Theses" database to identify unpublished PhD and Master's theses. The search terms and number of identified references are listed in Supplementary Table S1. An additional 16 studies were identified through other sources such as comprehensive literature reviews and references used in previously identified publications. After removing 38,322 duplicates, the remaining 28,305 hits were screened for suitability. Screening comprised reading both title and full abstract. In isolated cases, references were excluded solely based on title, for example, in case the title indicated that the reference was a review or meta-analysis without original data, or the topic of the reference was outside the scope of the present meta-analysis (e.g., "Persephone in the underworld: the motherless hero in novels by Burney, Radcliffe, Austen, Bronte, Eliot, and Woolf"). Some older PhD and Master's theses often did not have abstracts, in which case the whole thesis was screened. Details about the exclusion criteria and procedure during screening is provided in the Supplementary material.

Study Selection: Final Inclusion Criteria

Of the 2,984 references that were included after screening of abstract/title, 72 full-texts could not be obtained. The remaining 2,912 references then underwent a full-text search for eligibility. Inclusion criteria were:

(1) Use of phonemic/semantic fluency and/or verbal episodic memory (recognition/recall) tests that comply with the aforementioned definitions of verbal fluency and verbal episodic memory. Examples for verbal fluency are the Controlled Oral Word Association Test (COWAT; Benton, 1967) or the F-A-S Test (Spreen & Benton, 1977), the Thurstone Word Fluency Test (Thurstone & Thurstone, 1962), or any test in which participants had to generate as many words as possible starting/ending with, or containing certain letters, as well as providing as many examples as possible for a specific category. Not included were data from tests such as finding synonyms or essay writing (which were considered too peripheral for verbal fluency). Anagram tasks were excluded on the grounds that they draw on numerical and spatial abilities (Wilson et al., 1954).

For verbal episodic memory, we excluded tasks that measured exclusively or predominantly working memory such as Digit span forwards or backwards from the Wechsler Adult Intelligence Scales (Wechsler, 2008). Examples for included verbal episodic memory tests are the Visual Verbal Learning Test (Brand & Jolles, 1985), the RAVLT, and the CVLT. Logical Memory II and Logical Memory Recognition (remembering a story) from the WMS were included but not Logical Memory I, because this subtest is more related to verbal working memory. If multiple verbal episodic memory parameters were provided (e.g., delayed recall, total recall, recall), we retained the total score; otherwise, the provided scores were kept. Learning in all verbal episodic memory measures had to be intentionally (i.e., incidental learning measures were not included).

(2) For both verbal fluency and episodic memory, we excluded tasks that employed emotional stimuli, as they could be confounded with sex/gender differences in emotional processing (Kret & De Gelder, 2012; Stevens & Hamann, 2012). For example, affective semantic fluency categories such as 'pleasant/unpleasant' or 'joy/fear' (e.g., Gawda & Szepietowska, 2013a, 2013b) were not included.

(3) Verbal fluency/episodic memory stimuli were not presented laterally, that is, to one specific hemisphere. For example, tasks that employed laterality paradigms were not considered because of sex/gender differences in hemispheric asymmetry (Hirnstein et al., 2019).

(4) Verbal fluency/episodic memory tasks were not performed simultaneously with other tasks, as multitasking abilities might vary across men and women (Hirnstein et al., 2018).

(5) The publication contained quantitative, empirical data (i.e., no reviews, study protocols, meta-analyses, etc.), which allowed computation of the effect size, as well as the exact number (or percentages) of male and female participants. Only "pure" verbal fluency and verbal episodic memory measures were included. That is, if covariates such as intelligence had

been factored in, the data was excluded. If only aggregate scores were provided from test batteries comprising both eligible and not eligible tasks, data were excluded. Finally, when studies reported multiple verbal fluency/episodic memory tasks, but only provided statistical parameters to compute effect sizes for tests that found significant sex/gender differences – and insufficient statistical parameters for tests that did not find sex/gender differences – the whole study was discarded to avoid introducing a bias towards significant results.

(6) There were at least 10 male and 10 female participants in the sample to mitigate the effect of spurious findings with very small sample sizes.

(7) Participants were healthy individuals without a mental or other condition that could affect verbal fluency/episodic memory performance (e.g., depression, Alzheimer's disease, learning disability) and were not under the influence of any kind of substance, medicine or other factors that might influence cognitive performance (e.g., sleep deprivation, noise exposure, etc.). Data from control groups could be included, unless controls were selected for specific features (e.g., intelligence, age, socioeconomic status) to match clinical groups.

(8) Participants were not preselected for a specific feature that could potentially be related to verbal fluency/episodic memory performance (e.g., participants with certain gene combination(s), participants who performed better than average on a creativity test, samples with homosexual participants only).

(9) The publication was written in English, German, or any Scandinavian language.

(10) Cohen's *d* was outside the range of -4.0 to 4.0, which we deemed unrealistic. The range of included effect sizes was -1.07 to 1.42.

Where inclusion criteria were met but the study lacked important quantitative information (e.g., number of men/women/boys/girls, means, or *p*-values), authors were contacted with a request to provide the relevant data and other relevant data they have or know of. Out of 45 contacted authors, nine provided relevant data.

In total, 496 effect sizes from 168 references were included for quantitative analysis, comprising data from 355,173 participants (men/boys = 178,409, women/girls = 176,764). For a more detailed overview of the study selection process including reasons that led to exclusion, see Figure 1. For a complete list of all included references and effect sizes, see Supplementary Table S2.

Statistical Analysis

For each relevant measure from the included references above, standardized differences in means (Cohen's *d*) were computed based on the available statistical information. If the male/female distribution was given in percentages, they were converted into integers. The effect direction was set such that positively signed values indicate a female advantage and negatively signed values a male advantage. A value of zero indicates the absence of any male/female advantage. We consistently applied the random-effects model, because (a) we expected substantial between-study variance and (b) we aimed to generalize our findings to the entire population. Moreover, we consistently used subgroups within a reference as the unit of analysis (as opposed to using the whole reference as the unit of analysis). That is, if a study included a verbal episodic memory measure from two age groups (e.g., one 50-59 years and another 60-69 years), those subgroups were treated as separate measures, rather than combining them into one measure.

Several studies reported multiple outcomes for each (sub-)sample. For example, a study could provide data from two different tests that both measure recall. It is likely that those tests were correlated with each other and the magnitude of that correlation impacts the variance, and thus the likelihood of finding statistically significant results (Borenstein et al., 2009). Since these correlations were rarely reported, we ran each analysis twice: once with $r = 0$, assuming perfect *independence* of the outcomes, and once with $r = 1.0$, assuming perfect *correlation* between outcomes. In most cases, the results of both analyses yielded similar results. For ease of reading, we always reported the perfect independence results first. All tables/figures were based on the assumption of perfect independence.

Overall Sex/Gender Effects

First, we computed the overall sex/gender effect, separately for verbal fluency and verbal episodic memory. Then, we computed the overall sex/gender effect for each of the following four verbal ability measures: Phonemic and semantic fluency as measures of verbal fluency as well as recognition and recall as measures of verbal episodic memory. One study had aggregated phonemic and semantic fluency scores into a combined verbal fluency score (DeWan, 2006), while another had aggregated recognition and recall scores into combined verbal episodic memory scores (Rouch et al., 2005). Effect sizes from these studies were thus kept in the overall verbal fluency/episodic memory analysis but excluded from the recognition/recall/phonemic/semantic fluency analysis.

For all these analyses, we provided *Q*-statistic (testing the null hypothesis that all studies in the analysis shared a common effect size), I^2 (the proportion of observed variance that reflects difference in true effect sizes, rather than sampling error), and T^2 (the variance of true effect sizes) as indicators of how much the sex/gender effect varied across studies. To address the issue of publication bias, we reported Egger's regression (two-tailed) (Egger et al., 1997) and funnel plots (see Supplementary Figure S1).

Effects of Publication Year, Publication Type, Age, and Gender of First/last Author

To investigate whether sex/gender differences change with publication year (as an indicator for changes over time), vary across publication type (articles versus PhD/Master theses), age, and the gender of the first/last author, we ran a set of *meta-regressions*. Meta-regressions have the advantage that they allow investigating the effect of one factor while controlling for a set of other factors (Borenstein et al., 2009). Here again, we assumed that the true effect size varied across studies and thus applied a random-effects model (method of moments). All tests were two-sided, based on Z-distribution.

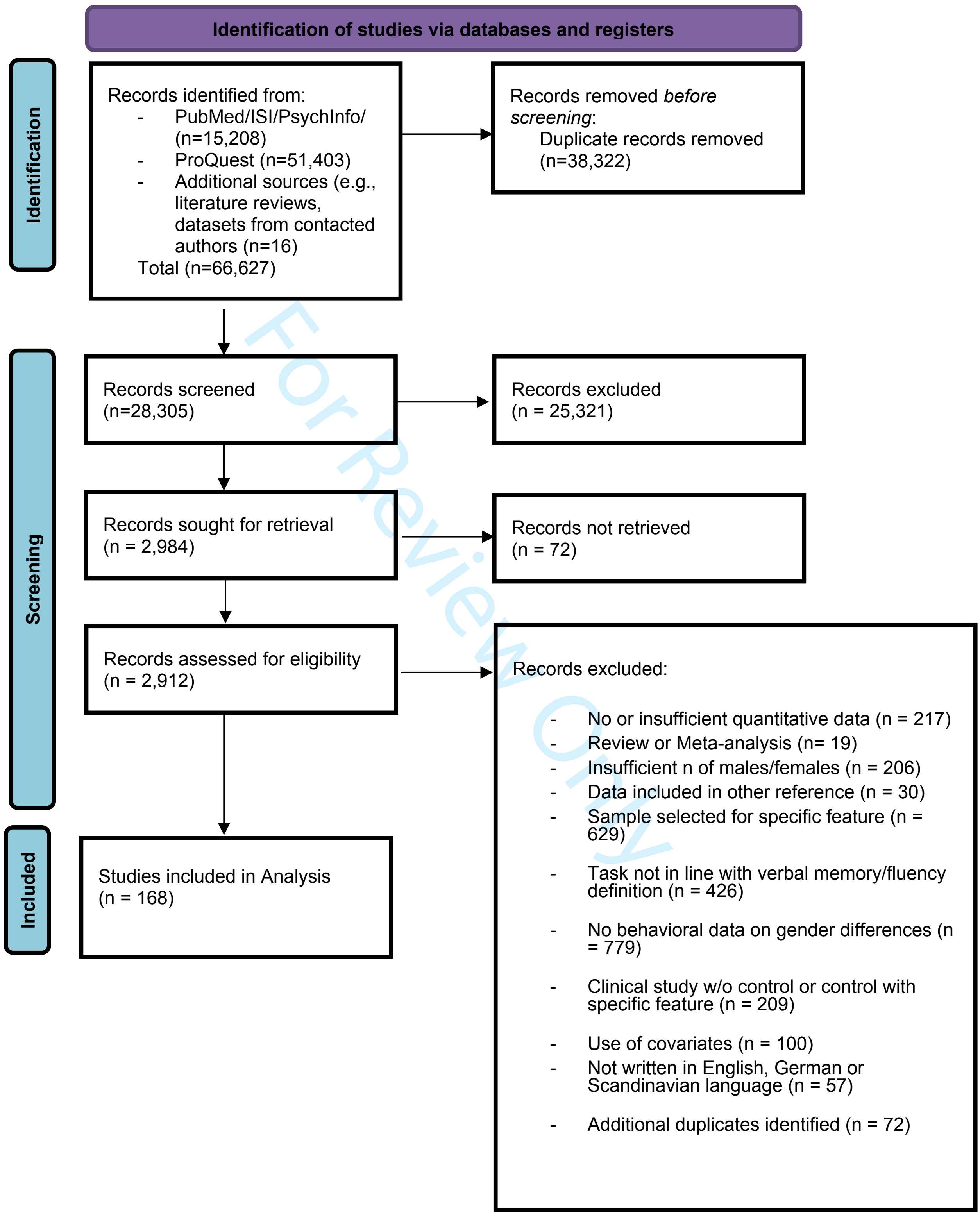
Six covariates were created for the meta-regressions: (1) The continuous covariate “Publication year" simply coded the year when a reference was published. (2) “Publication type” was a categorical covariate that could either be “Published article” or “PhD/Master’s thesis”. (3) Age was analyzed with two covariates: “Mean age” as a continuous variable, which was either obtained directly from the corresponding reference or, in case that information was missing, computed based on the age range (e.g., an age range of 40-60 years would lead to a mean age of 50 years). If age ranges were provided separately for men/boys and women/girls, we took the youngest and oldest age from either sex/gender. If mean ages were provided separately for women/girls and men/boys, we calculated a weighted overall mean. Using “Mean age” alone, however, has two shortcomings. First, several studies only provide age information such as “>70 years”, making it impossible to calculate a mean. Second, many studies have enormous age ranges. For example, ca. 20% of studies had age ranges of 40 years and more, rendering “Mean age” a rather coarse indicator. (4) For this reason, we created a second covariate to examine age effects: “Age groups”. This was a categorical covariate, theoretically grounded in the Medical Subject Heading (MeSh), the standardized vocabulary used in the Medline database for indexing, developed by National Library of Medicine. According to this classification, the following age categories were formed: “Child/Child preschool” (2-12 years), “Adolescent” (13-18 years), “Adult” (19-44 years), “Middle aged” (45-64 years), and “Aged” (65+ years). Effect sizes were grouped into those categories based on the reported age range of the corresponding study. For example, an effect size based on a sample with an age range of 20-27 years, was classified as “Adult”. An effect size based on an age range of 17-40 years was coded blank and excluded from the “Age groups” analysis. As a consequence, the number of effect sizes was substantially higher for “Mean age” (92%, 455/497) than for “Age groups” (51%, 253/497). While both age measures have their respective shortcomings, we combined both as this allows a reasonable estimate of age effects (see also Voyer et al., 2021). Finally, (5) and (6) were the categorical covariates “First author gender” and “Last author gender”, respectively, which was either male or female. In case of single-author studies, this was coded as first author and was not included for analysis of last author effects.

The categorical covariates described above were dummy-coded in order to be entered into the meta-regression. This was done such that “Published articles”, “Males”, and "Adult” served as reference groups for “Publication type”, “First/last author gender”, and “Age groups”, respectively. We did not include language as a covariate, because there were too few non-English reports of data. For comparison: 263 out of 496 effect sizes (53%) were reported in English, while the second most frequent language, Dutch, only comprised 40 effect sizes (8%).

We ran a sequence of meta-regressions for each verbal ability (i.e., recall, recognition, phonemic/semantic fluency) separately. The first meta-regression always included the covariates “Publication year”, “Mean age”, “Publication type”, and “First author gender”. This was done to maximize the number of available effect sizes. “Age groups” was not entered into the first meta-regression because of multicollinearity with “Mean age” and because only half of the effect sizes could be assigned to a specific age group (see above). We thus ran a second meta-regression that included “Age group” and all significant covariates from the first meta-regression as a control (except for “Mean age” due to multicollinearity). “Last author gender” was also not entered into the first meta-regression because of multicollinearity with “Publication type”: None of the PhD/Master’s theses have a last author. Therefore, we ran a third meta-regression for “Published articles” only that included “Last author gender” and all significant covariates from the first meta-regression as a control (except for “Publication type” due to multicollinearity).

Figure 1

PRISMA Flow Diagram Showing the Study Selection Process



Results

Overall Sex/Gender Differences

Effect sizes of the most frequent verbal fluency and verbal episodic memory measures are presented in Table 1.

Verbal Fluency

Assuming perfect independence between multiple outcomes within the same study, the overall effect size was $d = 0.07$ with a 95% confidence interval (CI) of 0.04 to 0.10, based on 290 effect sizes. The female advantage deviated significantly from zero with $Z = 5.10$, $p < .001$. There was substantial heterogeneity among studies ($Q(289) = 2085.1$, $p < .001$, $I^2 = 86.1$ %, $T^2 = 0.02$). Egger's regression intercept of -0.10 was not significant, $t(288) = 0.54$, $p = .591$.

Assuming perfect correlation between multiple outcomes within the same study, all effects remained significant/non-significant: $d = 0.07$, 95% CI [0.04 0.10], $Z = 4.60$, $p < .001$, $Q(209) = 1784.3$, $p < .001$, $I^2 = 88.3$ %, $T^2 = 0.02$, Egger's intercept = -0.13, $t(208) = 0.52$. $p = .602$, 210 effect sizes.

Verbal Episodic Memory

Assuming perfect independence, there was a significant female advantage with $d = 0.23$, 95% CI [0.19 0.26], $Z = 13.09$, $p < .001$, based on 206 effect sizes. Heterogeneity was substantial ($Q(205) = 1622.7$, $p < .001$, $I^2 = 87.4$ %, $T^2 = 0.04$). Egger's intercept was 1.08, $t(204) = 3.94$, $p < .001$. Assuming perfect correlation, all effects remained significant/non-significant: $d = 0.26$, 95% CI [0.21 0.30], $Z = 11.39$, $p < .001$, $Q(132) = 1194.1$, $p < .001$, $I^2 = 88.9$ %, $T^2 = 0.04$, Egger's intercept = 1.18, $t(131) = 3.45$, $p < .001$, 133 effect sizes.

Phonemic Fluency

There was a significant female advantage with an effect size $d = 0.13$, 95% CI [0.09 0.16], $Z = 6.75$, $p < .001$, based on 135 effect sizes. There was significant heterogeneity ($Q(134) = 272.3$, $p < .001$, $I^2 = 50.8$ %, $T^2 = 0.01$). Egger's intercept was 0.19, $t(133) = 1.04$,

$p = .30$. Assuming perfect correlation, all effects remained significant/non-significant: $d = 0.12$, 95% CI [0.09 0.16], $Z = 6.97$, $p < .001$, $Q(128) = 226.9$, $p < .001$, $I^2 = 43.6$ %, $T^2 = 0.01$, Egger's intercept = 0.20, $t(127) = 1.14$. $p = .25$, 129 effect sizes.]

Semantic Fluency

There was no significant sex/gender difference in semantic fluency with $d = 0.02$, 95% CI [-0.02 0.06], $Z = 1.00$, $p = .315$, based on 147 effect sizes. The effect varied significantly across studies ($Q(146) = 1782.6$, $p < .001$, $I^2 = 91.8$ %, $T^2 = 0.03$) and Egger's intercept -0.61, $t(145) = 1.78$, $p = .078$. Assuming perfect correlation, all effects remained significant/nonsignificant: $d = 0.01$, 95% CI [-0.02 0.05], $Z = 0.70$, $p = .482$, $Q(136) = 1740.1$, $p < .001$, $I^2 = 92.2$ %, $T^2 = 0.03$, Egger's intercept = -0.68, $t(135) = 1.86$. $p = .065$, 137 effect sizes.

Recall

There was a significant female advantage with $d = 0.28$, 95% CI [0.23 0.32], $Z = 12.54$, $p < .001$, based on 136 effect sizes. The effect varied largely between studies ($Q(135) = 1217.0$, $p < .001$, $I^2 = 88.9\%$, $T^2 = 0.04$). Egger's intercept was 1.32, $t(134) = 3.94$, $p < .001$. Assuming perfect correlation, all effects remained significant/non-significant: $d = 0.28$, 95% CI [0.24 0.33], $Z = 11.90$, $p < .001$, $Q(123) = 1155.3$, $p < .001$, $I^2 = 89.4$ %, $T^2 = 0.04$, Egger's intercept = 1.35, $t(123) = 3.85$. $p < .001$, 124 effect sizes.

Recognition

There was a significant female advantage with $d = 0.12$, 95% CI [0.06 0.17], $Z = 4.42$, $p < .001$, 66 effect sizes. The effect varied significantly across studies ($Q(65) = 257.1$, $p < .001$, $I^2 = 74.7$ %, $T^2 = 0.02$). Egger's intercept was 1.27, $t(64) = 3.11$, $p = .003$. Assuming perfect correlation, all effects remained significant/non-significant: $d = 0.17$, 95% CI [0.10 0.24], $Z = 4.78$, $p < .001$, $Q(49) = 164.9$, $p < .001$, $I^2 = 70.3$ %, $T^2 = 0.03$, Egger's intercept = 1.08, $t(48) = 2.42$. $p = .019$, 50 effect sizes.

Table 1

Descriptive overview of sex/gender differences in verbal fluency and verbal episodic memory measures

Verbal ability	Test/Measure	Effect size
Verbal fluency	**Total effect**	***d* = 0.07 (0.04 to 0.10) *k*=290**
Phonemic fluency	**Total effect**	***d* = 0.13 (0.09 to 0.16) *k*=135**
	Generic starting letter(s)	*d* = 0.12 (0.07 to 0.18) *k*=59
	COWAT/F, A, S	*d* = 0.14 (0.08 to 0.20) *k*=55
	Four-word sentences	*d* = 0.03 (-0.20 to 0.26) *k*=5
Semantic fluency	**Total effect**	***d* = 0.02 (-0.02 to 0.06) *k*=147**
	Category: Animals	*d* = -0.13 (-0.16 to -0.09), *k*=58
	Categories Animals & fruits/vegetables/food	*d* = 0.11 (0.03 to 0.18), *k*=26
	Objects with specific color	*d* = 0.19 (0.13 to 0.25), *k*=10
	Categories Animals, fruits/vegetables/food, & action verbs	*d* = 0.25 (-0.03 to 0.53), *k*=8
	Fruits/vegetables/food	*d* = 0.31 (0.16 to 0.47), *k*=8
Verbal episodic memory	**Total effect**	***d* = 0.23 (0.19 to 0.26) *k*=206**
Recall	**Total effect**	***d* = 0.28 (0.23 to 0.32), *k*=136**
	California Verbal Learning Test	*d* = 0.42 (0.32 to 0.52), *k*=28
	Rey Auditory Verbal Learning Test	*d* = 0.39 (0.29 to 0.48), *k*=24
	Generic word list	*d* = 0.17 (0.06 to 0.28), *k*=16
	Delayed Memory for Names/Visual-Auditory Learning from Woodcock Johnson Psycho-Educational Battery - Revised	*d* = -0.13 (-0.27 to 0.01), *k*=12
	10 Word Learning Test from CERAD	*d* = 0.18 (0.07 to 0.28), *k*=10
	Ten-Words Test	*d* = 0.26 (0.13 to 0.39), *k*=7
	Deese, Roediger and McDermott task	*d* = 0.15 (0.02 to 0.28), *k*=7
Recognition	**Total effect**	***d* = 0.12 (0.06 to 0.17), *k*=66**
	Rey Auditory Verbal Learning Test	*d* = 0.22 (0.12 to 0.33), *k*=18
	California Verbal Learning Test	*d* = 0.17 (0.06 to 0.29), *k*=13
	Deese, Roediger and McDermott task	*d* = 0.15 (0.04 to 0.27), *k*=7
	Story telling delayed recognition	*d* = -0.07 (-0.18 to 0.04), *k*=7
	Story telling immediate recognition	*d* = 0.02 (-0.09 to 0.13), *k*=7

Note. Values in parentheses represent 95% CI and k = number of effect sizes included. Effect sizes are provided assuming independence between multiple outcomes within the same study. Effect sizes within each sub-category were combined with a random-effects model, assuming a common among study variance component across sub-categories. That is, T^2 was computed for each age group and then pooled across subgroups. Only tests with at least seven effect sizes are provided, with the exception of phonemic fluency, where the three most frequent tests are provided.

Meta-regressions for Moderator Variables

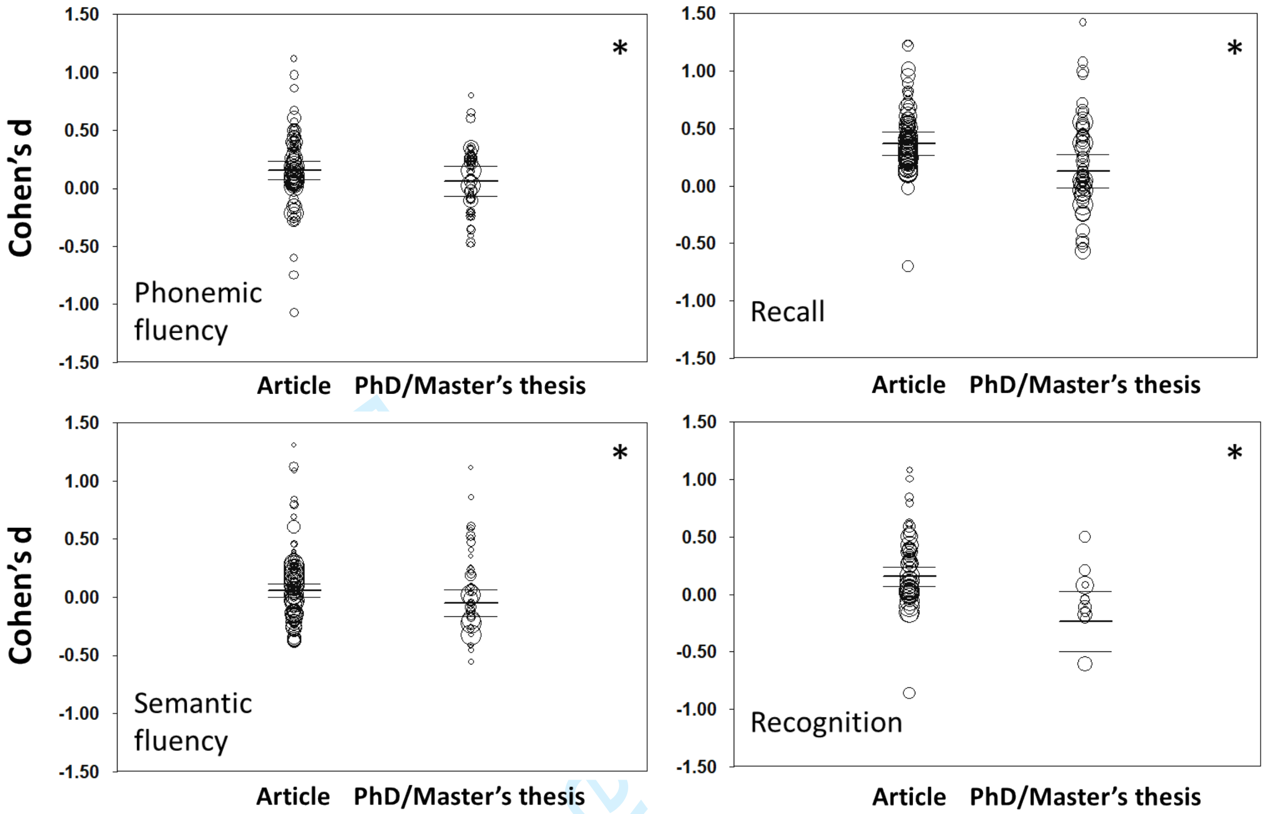
The first set of meta-regressions contained the predictors “Publication year”, “Publication type”, “First author gender”, and “Mean age”. Assuming perfect independence, all four models explained a significant proportion of between-study variance: Phonemic fluency ($Q(4) = 15.75$, $p = .003$, $R^2 = 3.6$, 125 effect sizes), semantic fluency ($Q(4) = 28.94$, $p < .001$, $R^2 = 51.0\%$, 129 effect sizes), recall ($Q(4) = 28.76$, $p < .001$, $R^2 = 23.5\%$, 124 effect sizes), and recognition ($Q(4) = 33.03$, $p < .001$, $R^2 = 31.3\%$, 65 effect sizes). Assuming perfect correlation, all four models remained significant: Phonemic fluency ($Q(4) = 18.04$, $p = .001$, $R^2 = 11.2\%$, 119 effect sizes), semantic fluency ($Q(4) = 35.66$, $p < .001$, $R^2 = 53.2$, 120 effect sizes, recall ($Q(4) = 25.89$, $p < .001$, $R^2 = 23.9$, 111 effect sizes), and recognition ($Q(4) = 23.80$, $p < .001$, $R^2 = 36.2$, 49 effect sizes).

Published Articles versus PhD/Master’s Theses

Published articles consistently reported significantly higher female performance than PhD/Master’s theses: Phonemic fluency ($Z = 2.00$, $p = .045$, $B = -0.093$), semantic fluency ($Z = 2.77$, $p = .006$, $B = -0.108$), recall ($Z = 4.01$, $p < .001$, $B = -0.243$), and recognition ($Z = 4.58$, $p < .001$, $B = -0.390$), see Figure 2. Assuming perfect correlation, all four effects remained significant.

Figure 2

Effect of publication type



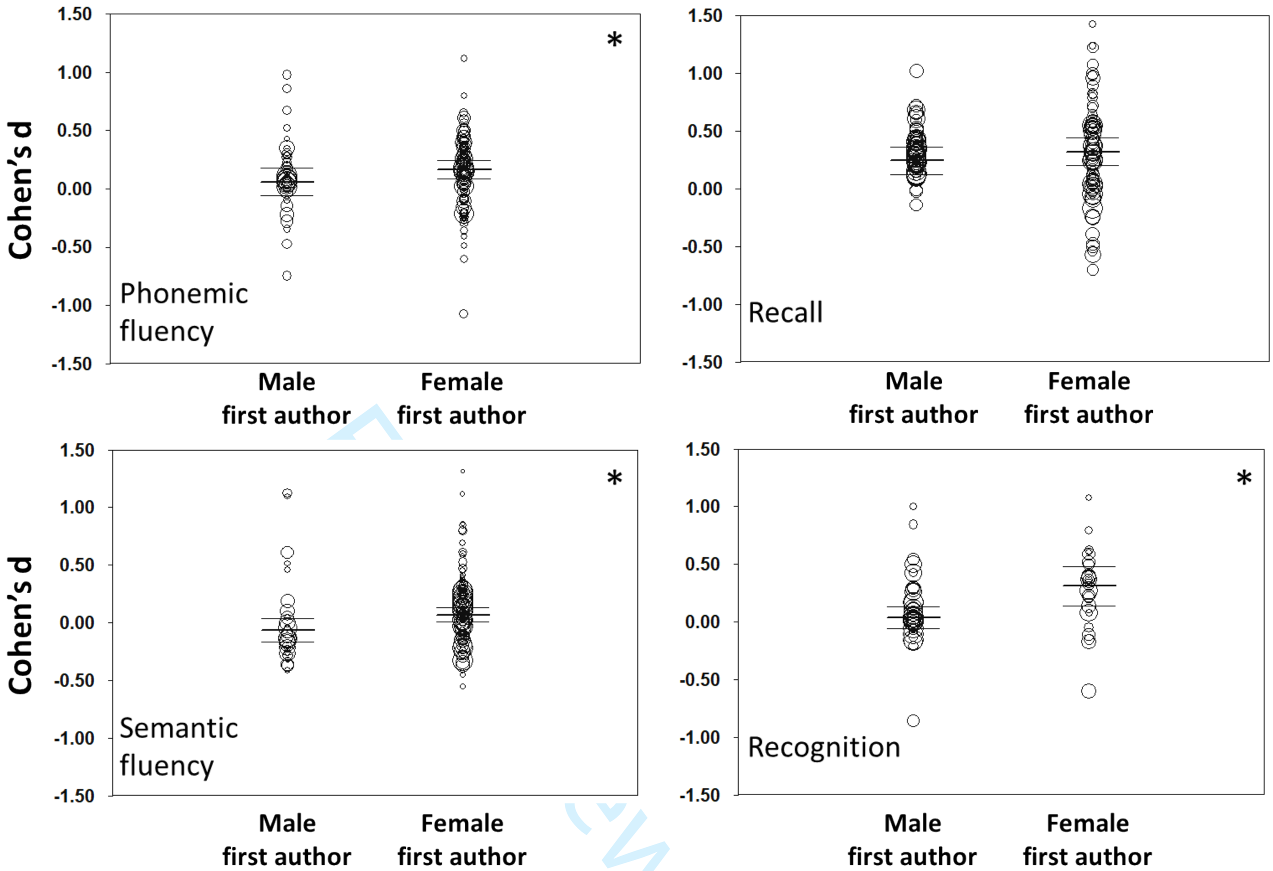
Note. * denotes significant difference between published articles and PhD/Master's theses. Central lines represent means of the respective category, upper and lower lines are confidence intervals. Figures are based on assuming perfect independence between multiple measures from the same (sub-) sample.

Gender of First Author

Female first authors reported significantly stronger female advantages in phonemic fluency ($Z = 2.44$, $p = .015$, $B = 0.107$), semantic fluency ($Z = 3.69$, $p < .001$, $B = 0.134$), and recognition ($Z = 4.31$, $p < .001$, $B = 0.271$) as compared to male first authors, see Figure 3. No significant difference between male and female first authors emerged in recall ($Z = 1.36$, $p = .175$, $B = 0.076$). Assuming perfect correlation, all effects remained significant/non-significant.

Figure 3

Gender of first author effect



Note. * denotes significant difference between female and male first authors. Central lines represent means of the respective category, upper and lower lines are confidence intervals. Figures are based on assuming perfect independence between multiple measures from the same (sub-) sample.

Publication Year

The female advantage significantly decreased in phonemic fluency ($Z = 2.401$, $p = .016$, $B = -0.004$) and recall ($Z = 2.02$, $p = .044$, $B = -0.005$) with publication year. However, the effect would become non-significant in phonemic fluency, if the oldest study (Elias, 1951) was removed ($Z = 1.91$, p = .057, $B = -0.002$). Neither semantic fluency ($Z = 1.63$, $p = .103$, $B = -0.004$) nor recognition ($Z = 1.43$, $p = .152$, $B = -0.004$) changed significantly with publication year, see Supplementary Figure S2. Assuming perfect correlation, the effect in recall would no longer be significant ($Z = 1.73$, $p = .085$, $B = -0.005$) and all other effects remained non-significant (after removing Elias, 1951).

Mean Age

In phonemic fluency, the female advantage became significantly smaller with increasing mean age ($Z = 2.46$, $p = .014$, $B = -0.002$). By contrast, the female advantage became significantly larger with increasing mean age in recall ($Z = 2.07$, $p = .038$, $B = 0.002$). However, the effect was non-significant ($Z = 1.76$, $p = .078$, $B = 0.002$) after removing the study with the oldest mean age sample that also had an unusually high female advantage (Bleecker et al., 1988). No significant mean age effect emerged in semantic fluency ($Z = 1.94$, $p = .052$, $B = -0.001$) and recognition ($Z = 0.05$, $p = .959$, $B < -0.001$), see Supplementary Figure S3. Assuming perfect correlation, the female advantage decreased significantly with age in semantic fluency ($Z = 2.45$, $p = .014$, $B = -0.002$) and increased significantly in recall, also if Bleecker et al., (1988) is removed ($Z = 2.03$, $p = .043$, $B = 0.002$). All other effects remained significant/non-significant.

Age Groups

A new set of meta-regressions was computed which contained "Age groups" and all significant covariates from the first set of meta-regressions described above. "Mean age" was never retained due to multicollinearity with "Age groups".

The results are presented in Table 2. "Age groups" as a whole (i.e., with all age categories combined) only varied significantly in semantic fluency ($Q(4) = 102.6$, $p < .001$, 77 effect sizes). More specifically, the sex/gender difference in "Middle aged" ($Z = 2.01$, $p = .045$, $B = 0.093$), and "Aged" ($Z = 7.65$, $p < .001$, $B = -0.273$) differed significantly from the reference group "Adults". There was no significant difference between "Child/Child Preschool" as well as "Adolescent" with "Adult" (all $Z \leq 1.57$, all $p \geq .117$). Moreover, there were no significant overall effects "Age groups" in phonemic fluency ($Q(4) = 5.49$, $p = .241$, 63 effect sizes), recall ($Q(4) = 7.54$, $p = .110$, 67 effect sizes), and recognition ($Q(4) = 6.85$, $p = .144$, based on 35 effect sizes). In phonemic fluency (all $Z \leq 1.56$, all $p \geq .119$) also none of the individual age groups differed significantly from the reference group “Adult”. In recall, the “Child/child preschool” group had a significantly smaller female advantage than the “Adult” group ($Z = 2.15$, $p = .032$, $B = 0.200$). In recognition, the “Adolescent” ($Z = 2.11$, $p = .035$, $B = 0.275$) and “Child/child preschool” ($Z = 2.05$, $p = .040$, $B = 0.202$) groups had a significantly higher female advantage than the “Adult” reference group, but in case of adolescents this was based on only three effect sizes.

Assuming perfect correlation, all “Age groups” effects in phonemic fluency (63 effect sizes) and semantic fluency (74 effect sizes) remained significant/non-significant. In recall, “Age groups” as a whole remained non-significant, but now only the “Aged” subsample had a significantly smaller female advantage than “Adult” ($Z = 2.30$, $p = .021$, $B = -0.127$, 62 effect sizes). In recognition, “Age groups” as a whole remained non-significant and none of the individual age groups differed significantly from “Adults” (all $Z \leq 1.78$, all $p \geq .075$, 26 effect sizes).

Gender of Last Author

A third set of meta-regressions was computed for published articles only that contained “Last author gender” and all significant covariates from the respective first set of meta-regressions. “Publication Type” was not included due to multicollinearity. “Last author gender” only became significant in semantic fluency ($Z = 2.50$, $p < .001$, $B = -0.09$, 90 effect sizes), where male last authors reported a stronger female advantage than female last authors. No significant differences between male and female last authors emerged in phonemic fluency ($Z = 1.68$, $p = .0093$, $B = 0.087$, 72 effect sizes), recall ($Z = 0.72$, $p = .474$, $B = 0.031$, 70 effect sizes), and recognition ($Z = 0.35$, $p = .729$, $B = -0.021$, 53 effect sizes), see Supplementary Figure S4. Assuming perfect correlation, all effect remained significant/non-significant.

Table 2

Descriptive overview of age group effects

	Phonemic fluency	**Semantic fluency***	Recall	Recognition
Child/Child preschool (≤12 yrs)	*d* = 0.13	*d* = 0.09	***d* = 0.05***	***d* = 0.13***
	(0.06 to 0.25, *k*=29)	(-0.02 to 0.17, *k*=30)	(-0.06 to 0.17, *k*=15)	(-0.04 to 0.31, *k*=7)
Adolescent (13-18 yrs)	*d* = 0.22	*d* = 0.03	*d* = 0.13	***d* = 0.11***
	(0.03 to 0.41, *k*=5)	(-0.25 to 0.30, *k*=2)	(-0.06 to 0.31, *k*=7)	(-0.14 to 0.35, *k*=3)
Adult (19-44 yrs)	*d* = 0.24	*d* = 0.15	*d* = 0.28	*d* = 0.02
	(0.07 to 0.41, *k*=7)	(0.10 to 0.21, *k*=8)	(0.17 to 0.39, *k*=15)	(-0.10 to 0.13, *k*=9)
Middle aged (45-64 yrs)	*d* = 0.13	***d* = 0.25***	*d* = 0.34	*d* = 0.13
	(0.03 to 0.23, *k*=7)	(0.17 to 0.32, *k*=6)	(0.24 to 0.45, *k*=9)	(-0.04 to 0.28, *k*=6)
Aged (≥ 65 yrs)	*d* = 0.06	***d* = -0.10***	*d* = 0.17	*d* = 0.06
	(-0.03 to 0.15, *k*=15)	(-0.14 to -0.07, *k*=31)	(0.09 to 0.24, *k*=21)	(-0.09 to 0.21, *k*=10)

Note. Values in parentheses represent 95% CI and *k* = number of effect sizes included. Individual age groups marked with asterisk/bold print differed significantly from the reference group "Adult". Verbal ability measures marked with asterisk/bold print indicate that the sex/gender difference varied significantly across all age groups. This table may contain more effect sizes than the meta-regression because the meta regression only includes studies with info on all covariates. Figures are based on assuming perfect independence between multiple measures from the same (sub-)sample.

Discussion

Using a meta-analytical approach, we investigated whether women/girls perform better than men/boys in verbal fluency and verbal episodic memory with neutral stimuli that were memorized intentionally and which factors moderated the female advantage.

Small but Robust Female Advantage in Phonemic but not Semantic Fluency

Women/girls performed significantly better in phonemic fluency than men/boys ($d = 0.13$), but there was no significant female advantage in semantic fluency ($d = 0.01$ to 0.02). When combined into a single verbal fluency score, a significant female advantage remained ($d = 0.07$) but more by virtue of the large number of included effect sizes ($k = 290$). The female advantage is thus limited to phonemic fluency, and even here it is markedly lower than in the landmark meta-analysis by Hyde and Linn (1988), who reported a small effect ($d = 0.33$). This discrepancy might be partly due to a different definition of verbal fluency used in the present meta-analysis which also included a much larger number of studies (168 vs. 14), thereby providing higher precision.

The overall effect size for phonemic fluency ($d = 0.12$ to 0.13) is practically identical with both the COWAT/F-A-S ($d = 0.14$), the most frequently used test/starting letter combination, and when generic starting letters or combination of generic starting letters are combined ($d = 0.12$). To illustrate the magnitude of the female advantage: If men/boys report $M = 36$ words, an effect of $d = 0.14$ would translate into an advantage of roughly one and a half words for women/girls ($M = 37.4$), assuming a realistic standard deviation of 10 words.

The large number of studies and effect sizes in the present meta-analysis allowed testing whether the observed sex/gender difference in *semantic fluency* depended on the specific category participants were tasked with. The results revealed that men/boys generally named more "animals" ($d = -0.13$), while women/girls named more "fruits/food/vegetables" ($d = 0.31$). When both categories were combined, which several studies did, the effects size was slightly positive (*d* = 0.11), indicating a slight female advantage. These findings support the view that there is no overall female advantage in semantic fluency and that sex/gender differences are category-dependent (e.g., Laws, 2004; Sokołowski et al., 2020). Category-dependency is also likely to account in part for the enormous heterogeneity in semantic fluency: The proportion of observed variance that reflects difference in true effect sizes (rather than sampling error) was 92 %. Yet, further research is needed to study those categories in more detail.

Small but Robust Female Advantage in Verbal Episodic Memory

We found a significant female advantage for verbal episodic memory, in general, with effect sizes between *d* = 0.23 and *d* = 0.26. Further, the female advantage was stronger in recall (*d* = 0.28) than in recognition (*d* = 0.12 to 0.17). Both findings are in line with Asperholm et al. (2019) who reported an overall female advantage of *g* = 0.28 for episodic memory with verbal content as well as a female advantage for recall (*g* = 0.28 to 0.31) and recognition (*g* = 0.17). Note that the studies included in both meta-analyses had only little overlap, highlighting the robustness of the female advantage. Recognition is generally considered easier than recall (e.g., Postman et al., 1948). Therefore, the female advantage might be smaller in the less difficult recognition tasks.

The strongest female advantage arose for the CVLT (*d* = 0.42) and the RAVLT (*d* = 0.39). By contrast, the two combined tasks “Delayed Memory for Names” and “Visual-Auditory Learning” from the Woodcock Johnson Psycho-Educational Battery – Revised showed a male advantage (*d* = -0.13). However, since all twelve effect sizes were taken from the same study (Cotten, 1991), generalization of these findings is questionable. In recognition, the CVLT (*d* = 0.17) and RAVLT (*d* = 0.22) also demonstrated a female advantage. The only task showing a male advantage (i.e., “Story telling delayed recognition”) (*d* = -0.07) was not significant (confidence bands comprise zero), and again all seven effect sizes were from the same study (Murre et al., 2013). To illustrate the magnitude of the female advantage in verbal episodic memory, imagine a hypothetical study with the CVLT, in which participants need to memorize a list with 16 nouns. Assuming a realistic standard deviation of three words and M =10 for men, Cohen's d = 0.42 (the largest effect size found for verbal episodic memory) translates into a female advantage of roughly one single word (M = 11.26).

While the present meta-analysis, together with Asperholm et al. (2019), suggest a small but robust female advantage for verbal *episodic* memory, Voyer et al. (2021) demonstrated that the female advantage in verbal *working* memory is practically zero. The largest female advantage reported by the authors was g = 0.15 for free recall. This may be due to the fact that certain tasks, which showed a reliable female advantage in the present study, for example the CVLT, were also included in Voyer et al. (2021). The distinction between episodic long-term and working memory is not always clear cut, and there are good arguments why the CVLT taps into both memory processes. In general, however, the findings from all three meta-analyses suggest that the female advantage in verbal memory is not universal and emerges especially when information needs to be transferred to long-term memory while it is very small or absent in working memory.

The Female Advantage is Small But Relevant

By comparison, the female advantage in verbal episodic memory and phonemic fluency is smaller than in other verbal abilities, such as reading achievement (d = 0.23 to 0.68 Reilly, 2012; Stoet & Geary, 2013) or writing abilities (d = 0.53 to 0.61 Hedges & Nowell, 1995). In general, medium to large sex/gender differences were the exception which is in line with the 'gender similarity hypothesis' (Hyde, 2005, 2014), according to which most sex/gender differences are in the small to medium range.

Verbal episodic memory and phonemic fluency tasks are frequently used for assessing psychological impairments (Barker-Collo & Feigin, 2006; Collie & Maruff, 2000; Pennington

& Ozonoff, 1996). Given that the present study corroborates previous findings that standard tests such as CVLT (Kramer et al., 2003), RAVLT (Bleecker et al., 1988) and COWAT (Halari et al., 2005) reliably showed a female advantage, this implies that sex/gender should be taken into account when phonemic fluency and verbal episodic memory are used in the clinical/diagnostic context.

Stronger Female Advantage in Published Articles Than PhD/Master's Theses

We found support for the notion that the female advantage in verbal fluency and verbal episodic memory is subject to publication bias. Firstly, Egger's regression and the funnel plots (Figure S1) suggest a "small study effect" for verbal episodic memory, in general, as well as recall and recognition. That is, especially small studies with significant results favoring women/girls were more likely to be included in our meta-analysis than small studies favoring men/boys. Egger's regression, however, was not significant for verbal, phonemic, or semantic fluency, suggesting the small study effect is generally stronger in verbal episodic memory.

In addition, we found that the female advantage in all four reported verbal abilities was higher in published articles than in PhD/Master's theses. The difference ranged between $d = 0.09$ to 0.39. In fact, for recognition, the female advantage was not significant in PhD/Master's theses. By using meta-regressions, factors such as publication year, age, or first/last author gender were controlled for. Therefore, it is unlikely that the publication type effect was a mere artifact of, for instance, an overrepresentation of unpublished studies in a particular age group. Similarly, the publication bias is unlikely to arise from lower quality in non-peer-reviewed PhD/Master's theses: If this were the case, we would expect *randomly* weaker or larger sex/gender differences. However, we found *consistently* stronger female advantage in published articles. The most parsimonious explanation is therefore that studies are more likely to be published when they find the anticipated female advantage.

First Authors' Gender Impacts Sex/Gender Difference

The meta-regression further revealed that the first author's gender affects the magnitude of the sex/gender difference in phonemic fluency, semantic fluency, and recognition, but not recall. Both male and female first authors consistently reported stronger performance for members of their own gender. The effect was in the range of $d = 0.11$ to 0.27 and controlled for age, publication type, or publication year. Hyde and Linn (1988) reported a similar first author bias but with smaller effect size ($d = 0.07$) and across a wide range of verbal abilities. We speculate that the first author bias represents an in-group bias where members of one's own group are favored over out-group members. Based on these data, it is not possible to disentangle whether female first authors overreport or male first authors underreport the female advantage.

We also found a last author effect in semantic fluency, where male last authors reported a significantly stronger female advantage than female last authors. This result is difficult to interpret, because the sex/gender effect in semantic fluency is category-dependent, as described above. None of the other three measures (i.e., phonemic fluency, recall, and recognition) yielded significant last author effects, and thus we refrain from speculations regarding last author effects in the present study.

No Clear Cohort or Age Effects

The female advantage decreased significantly with publication year for recall (when assuming perfect independence between multiple outcomes), but the effect was small ($B = -0.004$) and did not emerge when assuming perfect correlation. No significant effect was found for recognition (see also Asperholm et al., 2019). Similarly, the significant publication year effect in phonemic fluency disappeared when one outlier was removed. Overall, sex/gender effects reported here were relatively stable over time.

Age effects were neither in line with the previously reported stronger deterioration in older men as compared to older women (Graves et al., 2017; Kramer et al., 2003; Rodriguez-

Aranda & Martinussen, 2006), nor with an inverted U-shaped curve with smaller sex/gender differences in earlier and later life (Asperholm et al., 2019). When the analysis was based on *mean age*, a significant coefficient (B = -0.002) was only found in phonemic fluency, implying that the female advantage was reduced by d = 0.02 over a ten-year period – a small effect. When the analysis was based on *age groups*, none of the three verbal ability measures that showed a reliable female advantage yielded a significant overall age groups effect. In some cases, certain age groups differed significantly from the adult reference group (see Table 3), but most comparisons with adults were not significant. In general, findings for the three measures that yielded a female advantage, indicated relatively stable sex/gender differences throughout life-span (see also de Frias et al., 2006).

Semantic fluency was the only verbal domain showing a significant overall age group effect: Middle aged participants (45-64 years, d = 0.25) showed the strongest female advantage, followed by adults (19-44 years, d = 0.15) and children (2-12 years, d = 0.09). Participants aged 65 or older even showed a significant male advantage (d = -0.10). However, we refrain from interpretations, as the female advantage was strongly category-dependent.

Limitations

Firstly, the statistical indicators showed considerable variance. The null hypothesis, according to which there is only one true underlying effect size, was violated in all analyses. To include data from very heterogeneous samples can be considered an asset, as it increases the generalizability of our findings. However, although we investigated several moderator variables, there are other potentially relevant factors that we did not examine such as (i) specific categories for semantic fluency, (ii) test language, (iii) mono- versus bilingual participants, and (iv) participants' country/region of origin. The fact that most studies were carried out in the US/UK and used native English-speaking participants might hamper generalizability. For example, while the female advantage in reading comprehension emerges in all countries, its magnitude also varies across countries (Reilly, 2012; Stoet & Geary, 2013).

Secondly, we analyzed age effects with two approaches (age means and age groups) that each have their advantages and disadvantages. "Age means" allowed including more effect sizes at the expense of precision, as the single number of age mean becomes meaningless in samples with large age ranges. "Age groups" allowed examining sex/gender differences in clearly defined developmental periods but at the expense of losing effect sizes that do not fall in an age category. As a result, some of the age groups have very few effect sizes (e.g., two or three) and we thus refrained from interpreting too much into significant differences between specific age groups. Conducting those analyses seemed nevertheless justified and the lack of clear age effects may in part be due to the complex nature of sex/gender differences across age.

Thirdly, we contacted authors whose work we had already identified as suitable for our meta-analysis and where only key statistical parameters were missing for calculating effect sizes. We did not reach out to authors who simply used tests/tasks that we considered as adequate, and we also did not contact forums or researchers in the field of verbal fluency/memory. We further only reached out to authors who provided contact details in published articles, which were unavailable for authors of PhD/Master's theses. Moreover, we did not include data from Google Scholar as the massive numbers of reference (more than 200,000) was simply unfeasible to process. Thus, although the present meta-analysis compiled a large body of data, we might have missed several primary studies.

Conclusion and Future Avenues

Based on data from 168 studies, 496 effect sizes, and 355,173 participants, the present meta-analysis suggests that a small but robust female advantage in verbal fluency and verbal episodic memory exists. With respect to verbal fluency, the female advantage only emerged in phonemic fluency, while sex/gender differences in semantic fluency appeared strongly category-dependent. The female advantage, especially in phonemic fluency, is smaller than previously shown (Hyde & Linn, 1988). However, phonemic fluency as well as verbal episodic memory measures are frequently used in psychological/diagnostic settings, highlighting the need for taking sex/gender effects into account. A discussion of how the female advantage arises and what the underlying brain mechanisms are, is beyond the scope of the present meta-analysis, but as argued for other cognitive sex/gender differences, we propose that the female advantage emerges from an intricate interaction of biological, psychological, and socio-cultural factors (Halpern, 2012; Halpern & Tan, 2001; Hausmann, 2017; Jäncke, 2018).

The female advantage is affected by publication bias in two forms: Published articles reported larger female advantages than unpublished research, and both male and female first authors reported better performance for participants of their own gender. While we found evidence for the existence of publication bias, it did not fully account for the female advantage reported here. Similar investigations of first/last authors effects in cognitive abilities in which men/boys typically excel (e.g., mental rotation) have been largely ignored so far.

In general, meta-analyses focusing on cognitive abilities favouring women/girls are rare (for notable exceptions see Asperholm et al., 2019; Voyer et al., 2007; Voyer et al., 2021; Voyer & Voyer, 2014). Apart from including additional factors listed above, future studies should examine whether similar effects are also present in cognitive domains that are assumed to favour men/boys. Finally, more studies should adopt a biopsychosocial approach and include more routinely sex/gender-related, non-binary factors (e.g., sex hormones, self-efficacy, gender stereotypes), and their interactions, that might explain individual differences in verbal abilities and other cognitive domains better than sex/gender.

Acknowledgments

We would like to thank Kylie Wong and Emily George for their tremendous help with the screening of references.

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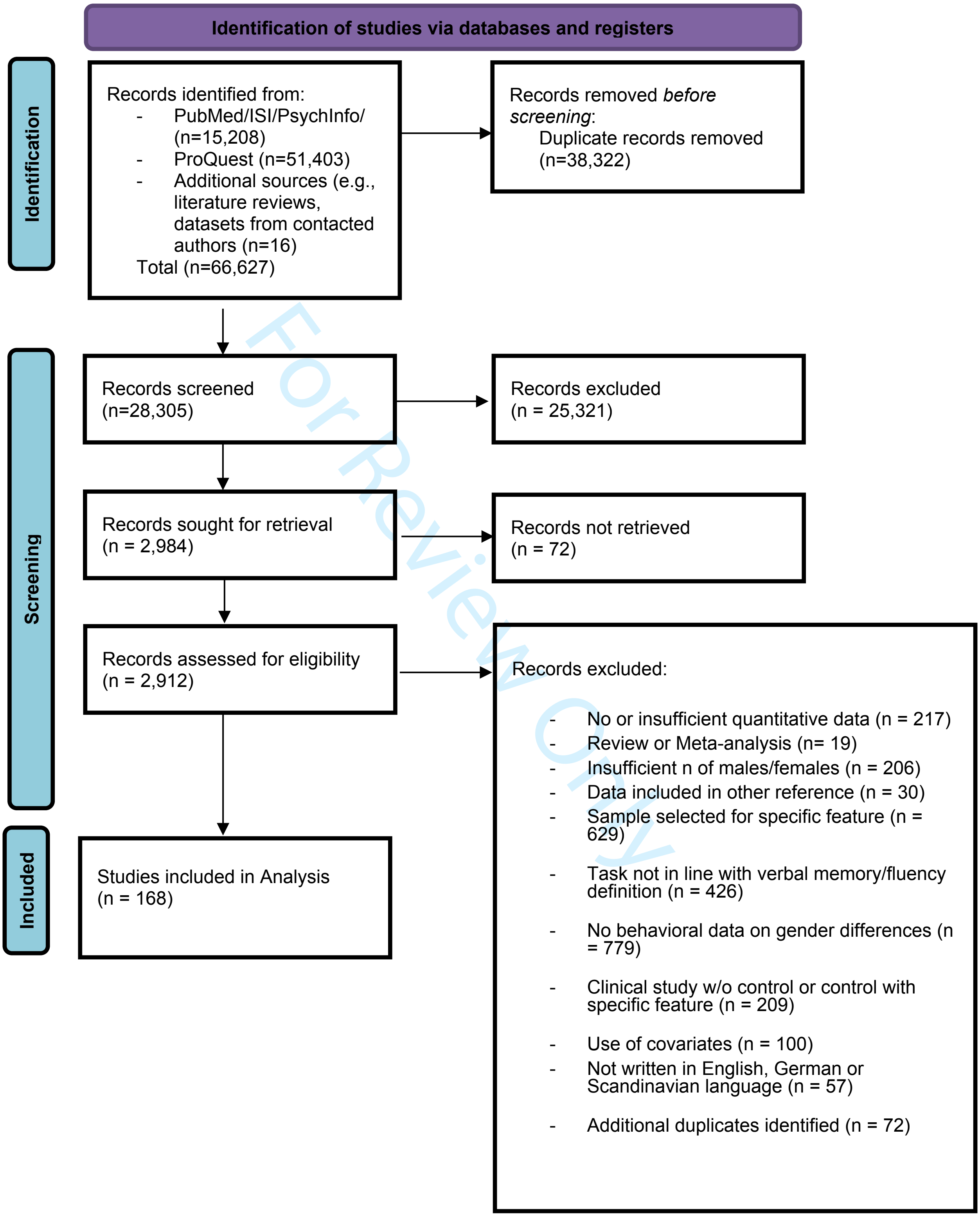
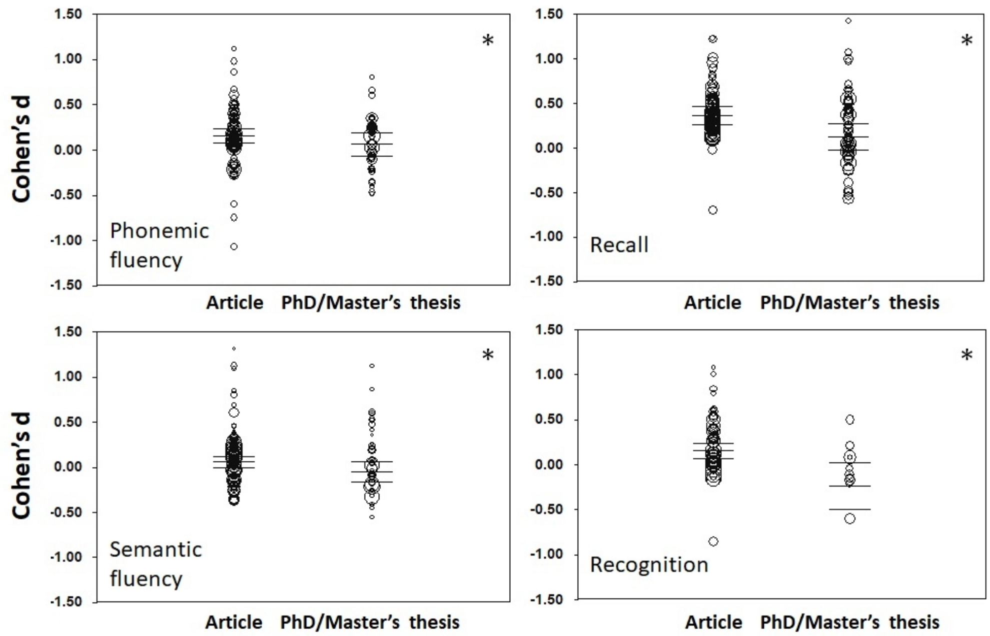
Figure 1

PRISMA Flow Diagram Showing the Study Selection Process





Effect of publication type

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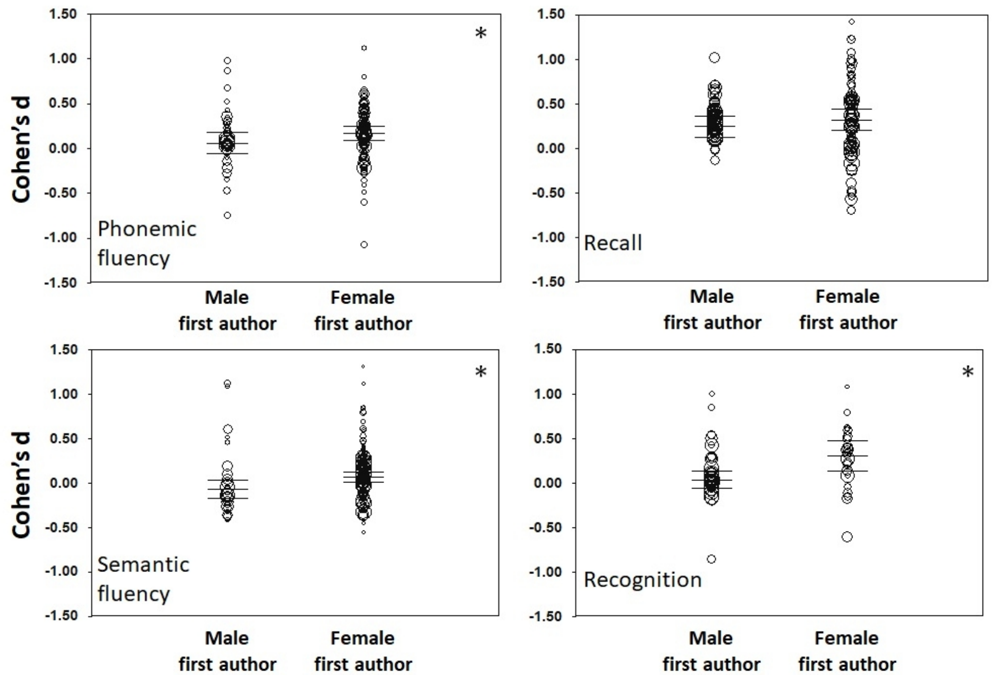

Gender of first author effect

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Table 1

Descriptive overview of sex/gender differences in verbal fluency and verbal episodic memory measures

Verbal ability	Test/Measure	Effect size
Verbal fluency	**Total effect**	***d* = 0.07 (0.04 to 0.10) *k*=290**
Phonemic fluency	**Total effect**	***d* = 0.13 (0.09 to 0.16) *k*=135**
	Generic starting letter(s)	*d* = 0.12 (0.07 to 0.18) *k*=59
	COWAT/F, A, S	*d* = 0.14 (0.08 to 0.20) *k*=55
	Four-word sentences	*d* = 0.03 (-0.20 to 0.26) *k*=5
Semantic fluency	**Total effect**	***d* = 0.02 (-0.02 to 0.06) *k*=147**
	Category: Animals	*d* = -0.13 (-0.16 to -0.09), *k*=58
	Categories Animals & fruits/vegetables/food	*d* = 0.11 (0.03 to 0.18), *k*=26
	Objects with specific color	*d* = 0.19 (0.13 to 0.25), *k*=10
	Categories Animals, fruits/vegetables/food, & action verbs	*d* = 0.25 (-0.03 to 0.53), *k*=8
	Fruits/vegetables/food	*d* = 0.31 (0.16 to 0.47), *k*=8
Verbal episodic memory	**Total effect**	***d* = 0.23 (0.19 to 0.26) *k*=206**
Recall	**Total effect**	***d* = 0.28 (0.23 to 0.32), *k*=136**
	California Verbal Learning Test	*d* = 0.42 (0.32 to 0.52), *k*=28
	Rey Auditory Verbal Learning Test	*d* = 0.39 (0.29 to 0.48), *k*=24
	Generic word list	*d* = 0.17 (0.06 to 0.28), *k*=16
	Delayed Memory for Names/Visual-Auditory Learning from Woodcock Johnson Psycho-Educational Battery - Revised	*d* = -0.13 (-0.27 to 0.01), *k*=12
	10 Word Learning Test from CERAD	*d* = 0.18 (0.07 to 0.28), *k*=10
	Ten-Words Test	*d* = 0.26 (0.13 to 0.39), *k*=7
	Deese, Roediger and McDermott task	*d* = 0.15 (0.02 to 0.28), *k*=7
Recognition	**Total effect**	***d* = 0.12 (0.06 to 0.17), *k*=66**
	Rey Auditory Verbal Learning Test	*d* = 0.22 (0.12 to 0.33), *k*=18
	California Verbal Learning Test	*d* = 0.17 (0.06 to 0.29), *k*=13
	Deese, Roediger and McDermott task	*d* = 0.15 (0.04 to 0.27), *k*=7
	Story telling delayed recognition	*d* = -0.07 (-0.18 to 0.04), *k*=7
	Story telling immediate recognition	*d* = 0.02 (-0.09 to 0.13), *k*=7

Note. Values in parentheses represent 95% CI and *k* = number of effect sizes included. Effect sizes are provided assuming independence between multiple outcomes within the same study. Effect sizes within each sub-category were combined with a random-effects model, assuming a common among study variance component across sub-categories. That is, T^2 was computed for each age group and then pooled across subgroups. Only tests with at least seven effect sizes are provided, with the exception of phonemic fluency, where the three most frequent tests are provided.

Table 2

Descriptive overview of age group effects

	Phonemic fluency	**Semantic fluency***	Recall	Recognition
Child/Child preschool (≤12 yrs)	*d* = 0.13	*d* = 0.09	***d* = 0.05***	***d* = 0.13***
	(0.06 to 0.25, *k*=29)	(-0.02 to 0.17, *k*=30)	(-0.06 to 0.17, *k*=15)	(-0.04 to 0.31, *k*=7)
Adolescent (13-18 yrs)	*d* = 0.22	*d* = 0.03	*d* = 0.13	***d* = 0.11***
	(0.03 to 0.41, *k*=5)	(-0.25 to 0.30, *k*=2)	(-0.06 to 0.31, *k*=7)	(-0.14 to 0.35, *k*=3)
Adult (19-44 yrs)	*d* = 0.24	*d* = 0.15	*d* = 0.28	*d* = 0.02
	(0.07 to 0.41, *k*=7)	(0.10 to 0.21, *k*=8)	(0.17 to 0.39, *k*=15)	(-0.10 to 0.13, *k*=9)
Middle aged (45-64 yrs)	*d* = 0.13	***d* = 0.25***	*d* = 0.34	*d* = 0.13
	(0.03 to 0.23, *k*=7)	(0.17 to 0.32, *k*=6)	(0.24 to 0.45, *k*=9)	(-0.04 to 0.28, *k*=6)
Aged (≥ 65 yrs)	*d* = 0.06	***d* = -0.10***	*d* = 0.17	*d* = 0.06
	(-0.03 to 0.15, *k*=15)	(-0.14 to -0.07, *k*=31)	(0.09 to 0.24, *k*=21)	(-0.09 to 0.21, *k*=10)

Note. Values in parentheses represent 95% CI and *k* = number of effect sizes included. Individual age groups marked with asterisk/bold print differed significantly from the reference group "Adult". Verbal ability measures marked with asterisk/bold print indicate that the sex/gender difference varied significantly across all age groups. This table may contain more effect sizes than the meta-regression because the meta regression only includes studies with info on all covariates. Figures are based on assuming perfect independence between multiple measures from the same (sub-)sample.