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A meta-analytic review of quantification methods for camouflaging behaviors in autistic and neurotypical individuals

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Camouflaging, a phenomenon observed in autistic individuals, refers to the conscious or unconscious strategies that individuals employ to mask, assimilate, or compensate for their autistic characteristics in social settings, in order to blend in or avoid stigmatization. These strategies may include suppression of behaviors considered atypical, imitation of neurotypical behaviors, and use of social scripts to navigate social interactions. While these behaviors have an adaptive goal, they have been linked with mental health issues. Our study examines the two assessment: Methods the Camouflaging Autistic Traits Questionnaire and the discrepancy method. Also examining differences based on sex and diagnosis. We conducted 17 independent meta-analyses, revealing significant differences between autistic individuals, with females displaying consistently higher scores. Autistic individuals showed higher scores when compared to their neurotypical counterparts. Meta-regression analysis suggests age as a relevant moderating factor, impacting comparisons between neurotypical groups. We discuss the differences in the assessment of camouflaging behaviors and the current strengths and limitations of both methods.

Keywords Camouflaging, CAT-Q, Discrepancy, Autism, Meta-analysis

Camouflaging is a phenomenon predominantly observed in the autistic population. It refers to behaviors aimed at adapting, imitating, hiding, or minimizing aspects of one's social conduct to meet the expectations of specific social environments[1–3]. Although autism is commonly defined as a neurodevelopmental condition marked by difficulties in social communication and the presence of restricted interests and repetitive behaviors, camouflaging has only recently been recognized as a distinct and relevant associated phenomenon[5,6].

In recent years, scholars have increasingly argued that autism should not be viewed solely as a disorder, but rather as a neurodevelopmental condition characterized by both challenges and differences in social communication and behavior[82]. While autistic individuals may face difficulties in social interaction and may display restricted and repetitive behaviors, many also possess notable strengths—such as heightened attention to detail, strong memory, deep focus on specific interests, and distinctive problem-solving abilities. This perspective is consistent with the principles of the neurodiversity movement, which views autism as a natural variation in human cognition and behavior, rather than a pathological deficit.

Currently, the preferred term according to the autistic community to refer to themselves is 'autistic individuals'[7] This aligns with the neurodiversity movement, which advocates for avoiding negative terms such as "disorder," "deficit," and "impairment," instead framing autism as a natural variation in human cognition and behavior[7,83,84]. Autistic individuals face challenges in various aspects of life, including communication, social interaction, and executive functions[8,9]. The estimated median prevalence of autism is around 100 cases per 10,000 inhabitants, with approximately 33% of these cases showing some degree of intellectual disability[10]. A diagnosis ratio of 4.2:1 between autistic males and females has been observed[10]; however, it is currently believed that there is significant underdiagnosis of autistic females[4,11–13]. One explanation lies in sex-related differences in the clinical presentation of autism[14–16]. Female autistic individuals often exhibit more advanced social-communicative and social-cognitive skills, which can obscure autistic traits during traditional assessments[17–21].

Several factors have been proposed to explain the higher prevalence of camouflaging strategies among autistic females compared to males. A primary factor involves gendered social expectations, which place a stronger emphasis on empathy, communication, and sociability in females. These societal pressures may compel autistic

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females to adopt camouflaging behaviors in order to align with expected gender roles. Additionally, females are often encouraged to be more emotionally expressive and socially engaged, prompting greater efforts to adapt to social contexts.

Another contributing factor is heightened sensitivity to social feedback. Autistic females may be more attuned to social cues and more skilled at observing and imitating neurotypical behaviors, leading to the development of more nuanced compensatory strategies. Enhanced language and social abilities may also facilitate camouflaging: compared to autistic males, autistic females often exhibit more advanced early language development and stronger superficial social skills, which can make their autistic traits less visible and contribute to underdiagnosis.

Camouflaging appears to be more prevalent and complex among autistic females[17,22,23]. These behaviors are thought to arise, in part, from gendered social expectations that place a higher emphasis on empathy, sociability, and emotional expression in women. This societal pressure may prompt autistic females to adopt strategies that help them conform to expected roles. Factors such as heightened sensitivity to social feedback and enhanced early language and social skills may further contribute to the development of more refined camouflaging strategies in autistic females compared to males.

Camouflaging involves both conscious and unconscious efforts to mask, compensate for, or suppress autistic traits to avoid stigma and achieve social acceptance[1,3,24]. These behaviors can serve as protective mechanisms against social exclusion[25]. Common examples include imitating facial expressions or gestures, forcing eye contact, or avoiding discussions of personal interests[17]. Hull and colleagues[26] proposed a model of camouflaging composed of three components: (a) *assimilation*, involving the adoption of neurotypical behaviors to fit in; (b) *masking*, or the suppression of autistic traits to prevent negative social consequences; and (c) *compensation*, referring to the use of learned strategies, such as social scripts, to navigate interactions.

To assess camouflaging, two broad methodological approaches have been developed: discrepancy methods and self-report measures. Discrepancy methods involve comparing the individual's external social behavior with their internal traits or cognitive abilities[22]. External behavior is typically measured with tools such as the Autism Diagnostic Observation Schedule[31]while internal traits are assessed using instruments such as the Reading the Mind in the Eyes Test[27]the Frith-Happé Animations[28]the Autism Spectrum Quotient[29]and the Social Responsiveness Scale[30].

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In turn, for measuring external behavior, the *Autism Diagnostic Observation Schedule*[31] is generally used[22,32–35]. On the other hand, self-report measures or reflective methods have also been used to assess this construct. Examples of questionnaires used to quantify camouflage are the *Comprehensive Autistic Trait Inventory*[36] (CATI), the *Girls Questionnaire for Autism Spectrum Condition*[37] (GQ-ASC), the *Cassidy Questionnaire*[38]and the *Camouflaging Autistic Traits Questionnaire*[26] (CAT-Q). The CATI measures autistic traits through 42 items grouped in six subscales: Social Interactions, Communication, Social Camouflage, Repetitive Behaviors, Cognitive Rigidity, and Sensory Sensitivity. The GQ-ASC assesses autism in females through 21 items categorized into five subscales: Imagination and Play, Camouflaging, Sensory Sensitivities, Socializing, and Interests. The Cassidy Questionnaire consists of a brief set of four questions that quantify the tendency of autistic adults to camouflage. The CAT-Q is a questionnaire of 25 items, which describes three main behaviors: assimilation, masking, and compensation. It should be noted that in CATI, GQ-ASC, and the Cassidy Questionnaire the primary aim of the questionnaire was not to provide a comprehensive characterization of camouflaging as a construct[65]. CATI and GQ-ASC were developed to assess autistic traits in females but were not specifically designed to measure camouflaging, while the Cassidy Questionnaire focuses on the relationship between camouflaging and suicidality. In contrast, CAT-Q details this phenomenon well through its three subscales, making it the most precise questionnaire to measure these camouflaging behaviors. This CAT-Q demonstrates several strengths, including good content validity, test-retest reliability, measurement invariance across diagnostic and gender groups, and emerging evidence of cross-cultural validity[26,65].

Recent research has increasingly documented the psychological costs of camouflaging in autistic individuals. Higher levels of camouflaging have been linked to interpersonal trauma, heightened anxiety and depression, lower self-esteem, reduced authenticity, and diminished engagement with the autistic community[40]. Similarly, van der Putten et al.[41] reported associations between camouflaging and poorer mental health outcomes among autistic adults. Notably, camouflaging has also been associated with increased suicidal thoughts and behaviors, potentially mediated by feelings of defeat, entrapment, and thwarted belongingness[79,80]. These findings underscore the need for a nuanced understanding of camouflaging as a potentially maladaptive coping strategy with serious implications for well-being.

Although both autistic males and females engage in camouflaging[2,22]it appears to be more common among females[42–44]. Early research has suggested that autistic females often present as more sociable and are more likely to mask their autistic traits, which may contribute to underdiagnosis or delayed identification[3,45,46]. These diagnostic challenges may prevent timely access to appropriate support and increase vulnerability to social isolation, manipulation, or abuse[47,48]. Moreover, across genders, the persistent effort to monitor and adjust one's behavior in social settings may lead to exhaustion, anxiety, depression, and difficulties in forming an authentic self-concept[2,49]. Thus, despite their adaptive intent, camouflaging behaviors can have long-term negative effects on psychological well-being[25,50].

Although camouflaging is most commonly associated with autism, it has also been reported in individuals with ADHD[51] and even among neurotypical adults[52]. However, most systematic reviews exclude neurotypical

groups, which may lead to misleading conclusions. Some differences attributed to autistic males and females may in fact reflect broader gender-based tendencies rather than diagnostic differences. Including neurotypical samples is therefore essential to disentangle gender effects from diagnostic effects.

Given the current evidence, it is crucial to determine whether camouflaging behaviors are indeed more pronounced in autistic females than in autistic males. To address this question, we adopt a dual-method approach using both the discrepancy method[22] and the CAT-Q[26]. This combination offers a robust framework for understanding camouflaging. The discrepancy method captures the gap between internal traits and external presentation, while the CAT-Q provides detailed self-report data aligned with theoretical models of camouflaging.

This integrated approach enables a more comprehensive analysis of sex differences in camouflaging behaviors and offers valuable insights into the underlying dynamics of social adaptation in autism. Although previous meta-analyses[64] have examined camouflaging behaviors, our study is, to our knowledge, the first to integrate both self-report and discrepancy-based assessment methods across multiple CAT-Q subscales, while also including comparisons not only between autistic males and females but also with neurotypical control groups. This broader analytical scope allows for a more nuanced understanding of camouflaging across diagnostic and sex-based categories. Furthermore, the studies included in our analysis span a wide age range—from childhood to adulthood—enabling us to examine whether camouflaging behaviors vary across developmental stages. Understanding the influence of age is crucial, as it may moderate camouflaging and shape the interpretation of sex differences in autism. Accordingly, this study seeks to determine whether the observed differences between autistic males and females in camouflaging are robust or potentially confounded by age-related factors.

Method

This study was pre-registered on the PROSPERO platform, under registration number CRD42023378812, on December 21, 2022. To ensure methodological rigor, the search and review process of the studies was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[53].

Search strategy

We performed an advanced search on the Web of Science, Scopus, and PubMed databases. The following search terms were used: ((autis*) AND ((camouflag*) OR (mask*) OR (compensat*) OR (pass*))). Published studies addressing camouflage in autistic individuals were conducted with no starting date restriction.

Eligibility criteria

We used the following inclusion criteria: (a) Studies examining the phenomenon of camouflage; (b) Studies using either the CAT-Q or discrepancy method for assessing camouflage; (c) Studies published in English; and (d) Scientific articles published in peer-reviewed journals. Studies fulfilling the inclusion criteria went through the following exclusion criteria: (a) Being a theoretical or review article; (b) Case studies; (c) Not providing quantitative measures of either the CAT-Q (total score with or whitout subscales score) or the discrepancy method for assessing camouflage; (d) Not providing quantitative evidence categorized by gender.

Two independent reviewers (ICB, CVH) were appointed to conduct the systematic search and apply the eligibility criteria. A third reviewer (RC) was appointed to resolve any discrepancies and ensure accuracy and consensus regarding eligibility and coding.

Assessment of quality

To evaluate the methodological rigor and potential biases in the studies included, we utilized the National Institute of Health's (NIH) "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies"[54]. This tool features 14 key areas of analysis, addressing essential elements such as the formulation of the research question, the characteristics of the studied population, recruitment methods, study power, exposure and outcome measurement techniques, dropout rates, and statistical methods. Each assessment question is classified as "yes," "no," "cannot determine," "not applicable," or "not -reported." For this study, we employed a scoring system where "yes" responses received a score of 1, partial answers were assigned 0.5 points, and "no" or unclear responses received a score of 0. Studies scoring seven or more points were classified as high quality (good), while those scoring between five and six points were deemed acceptable (fair). Studies with fewer than five points were categorized as poor quality. Two independent researchers conducted the quality assessment, and any discrepancies were resolved through detailed discussion. The results of the quality assessment are presented in Table 1.

Data extraction

All articles that were eligible for meta-analysis went through the data extraction process. Two independent reviewers (ICB, CVH) were in charge of reviewing the articles and extracting the required data: Type of assessment conducted (self-report/discrepancy), type of sample, mean age, sex distribution, instruments used, scores obtained, and main results.

Results

Study selection

The search was conducted until December 2024, retrieving 6,971 records from three databases (Scopus, Web of Science, and PubMed). We examined for duplicates by matching the digital object identifier (DOI) and title. Next, a manual check was conducted to ensure no duplicates remained. We found a total of 3,258 duplicate records, thus leaving a total of 3,713 individual documents to be examined for eligibility. Two independent

Authors	Criteria														Score	Quality rating
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14		
Lai et al. (2017)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Cage & Troxell-Whitman (2019)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	0.5	7.5	Good
Lai et al. (2019)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Schuck et al. (2019)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Hull, Lai et al. (2020)	1	1	1	1	1	NA	NA	NA	1	NA	1	1	1	1	10	Good
Jorgenson et al. (2020)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Cook et al. (2022)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Hull, et al. (2021)	1	1	1	1	1	NA	NA	NA	1	NA	1	0	1	1	9	Good
Jedrzejewska & Dewey (2022)	1	1	1	1	1	NA	NA	NA	1	NA	1	0	1	1	9	Good
Belcher et al. (2022)	1	1	1	1	1	NA	NA	NA	1	NA	1	0.5	1	1	9.5	Good
McQuaid et al. (2022)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Ross et al. (2023)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Milner et al. (2023)	1	1	1	1	0	NA	NA	NA	1	NA	1	0	1	1	8	Good
Walsh et al. (2023)	1	1	1	1	0.5	NA	NA	NA	1	NA	1	0	1	1	8.5	Good
Oshima et al. (2024)	1	1	1	1	0.5	NA	NA	NA	1	NA	1	0	1	1	8.5	Good

Table 1. Quality assessment. NA = Not applicable.

reviewers (ICB, CVH) conducted the study selection process based on the established inclusion and exclusion criteria.

The first selection round was conducted by screening the title and abstract of the documents and examining for evidence of eligibility based on the established inclusion criteria. After this stage, 3,349 documents were excluded. The 364 remaining studies were examined for eligibility in a second round based on the established exclusion criteria. As a result, 349 studies were deemed not eligible for inclusion in the final analysis. In the end, a total of 16 studies provided sufficient quantitative data on camouflaging behavior scores using the discrepancy method or any of the subscales of the CAT-Q (compensation, masking, or assimilation) or its total score, which is required for inclusion in the meta-analysis. For the whole paper selection process, a concordance analysis was performed using Cohen's kappa coefficient, with an overall high level of agreement ($\kappa = 0.887$; $t = 7.732$; $p = .000$). The following data was extracted from each study: (a) Authors and year; (b) Details of the sample (sex, age, autism diagnosis status); (c) Summary of main findings (Supplementary Table S1); (d) discrepancy method or CAT-Q scores for autistic and neurotypical individuals, if reported (Supplementary Table S2). Specifically, the mean and standard deviation of the scores obtained by male and female participants was extracted.

Among the 16 eligible studies, one study had to be excluded from our quantitative analysis: a study by Bernardin et al.[55]as it shared the same sample and results from a previous study by Jorgenson et al.[56]so the former was excluded to avoid duplication. In the final stage, 15 studies were included in our quantitative synthesis. Four studies quantified camouflage using the discrepancy method, and 11 used the CAT-Q method. Figure 1 presents the flow diagram summarizing the study selection process.

Meta-analysis

In total, 15 independent studies provided sufficient quantitative data for inclusion. 17 separate meta-analyses were conducted: 16 based on the CAT-Q scores reported by autistic or neurotypical individuals and 1 for the discrepancy method. Results are presented in Table 2. Figures 2 and 3 illustrate the results for the CAT-Q total score (autistic females - autistic males) and discrepancy-based methods. Figures for the rest of the analyses conducted are reported in Supplementary Figures S1 to S15.

Seven studies were included when comparing autistic females and autistic males on the three main dimensions of the CAT-Q. Only five studies were included when considering neurotypical individuals, as two did not include data for this group. Consequently, analyses based solely on autistic subjects always contain two additional studies.

In general, results show a statistically significant difference between autistic females and autistic males across dimensions ($p = .000$), where the former group tends to show higher scores in average across all three camouflaging behaviors (Assimilation: $M_F = 34.450$; $SD_F = 8.756$; $M_M = 32.443$; $SD_M = 8.926$; Masking: $M_F = 32.070$; $SD_F = 8.756$; $M_M = 28.509$; $SD_M = 9.152$; Compensation: $M_F = 34.647$; $SD_F = 10.352$; $M_M = 31.310$; $SD_M = 10.278$).

When comparing the neurotypical groups, statistically significant differences were observed in the Masking ($p = .047$) and Compensation ($p = .017$) dimensions but not in Assimilation ($p = .455$). Comparisons between autistic and neurotypical groups for males and females show differences in the Assimilation and Compensation subscales only, where autistic individuals tend to show higher scores when compared to their neurotypical counterparts ($p = .000$). No differences were observed in the Masking dimension ($p \geq .073$).

Regarding the CAT-Q total score, 11 studies were included for comparisons between autistic females and autistic males, and 6 for comparisons including neurotypical groups. Results show statistically significant differences between autistic females and autistic males ($p = .013$), where the former group tended to exhibit higher scores on average ($M_F = 113.621$; $SD_F = 24.645$; $M_M = 106.378$; $SD_M = 22.421$). When comparing neurotypical groups for the CAT-Q total score, statistically significant differences were observed when comparing autistic

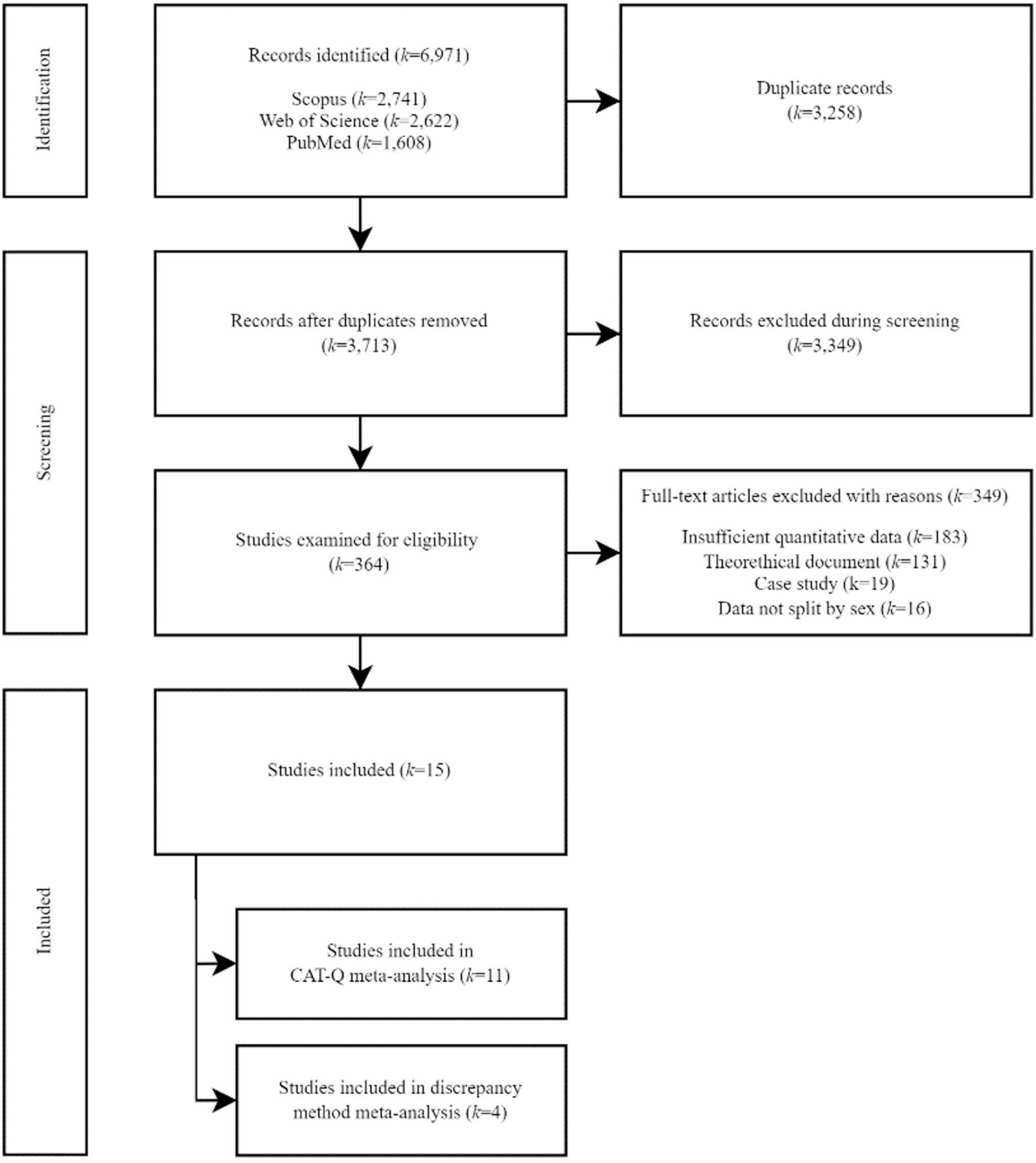

Fig. 1. Flow diagram for the study selection process.

with neurotypical females (p =.000) and autistic with neurotypical males (p =.000), but not when comparing between neurotypical males and females (p =.379).

Results for the discrepancy method meta-analysis showed a statistically significant difference between autistic males and females, where the camouflaging score obtained was higher for the female group in average (M_F=0.195; SD_F=0.541; M_F=−0.097; SD_F=0.592).

To aid interpretation, we report two key metrics of heterogeneity: Cochran's Q and I^2. Cochran's Q tests whether variability across studies is greater than would be expected by chance, while I^2 indicates the percentage of variance due to heterogeneity rather than sampling error. These metrics were applied to the CAT-Q and the discrepancy method.

			REM								Heterogeneity tests			Publication bias	
			k	d	SE	*p*	IC (95%)				Q	*p*	I^2	Z_{Egger}	*p*
CAT-Q	Assimilation	AUT Females - AUT Males	7	0.371	0.062	0.000	[0.249	-	0.494]		6.061	0.416	0.000	−1.489	0.137
		NT Females - NT Males	5	− 0.057	0.076	0.455	[−0.206	-	0.092]		1.102	0.175	0.010	1.102	0.271
		AUT Females - NT Females	5	1.500	0.275	0.000	[0.961	-	2.040]		21.278	0.000	0.855	0.741	0.459
		AUT Males - NT Males	5	1.147	0.145	0.000	[0.862	-	1.432]		1.124	0.038	0.422	2.662	0.008
	Masking	AUT Females - AUT Males	7	0.359	0.062	0.001	[0.237	-	0.481]		5.211	0.517	0.000	− 0.142	0.887
		NT Females - NT Males	5	− 0.151	0.076	0.047	[−0.300	-	− 0.002]		2.705	0.608	0.000	0.471	0.638
		AUT Females - NT Females	5	0.302	0.201	0.134	[−0.093	-	0.696]		15.499	0.004	0.774	0.235	0.814
		AUT Males - NT Males	5	− 0.259	0.145	0.073	[−0.542	-	0.024]		9.680	0.046	0.495	0.836	0.403
	Compensation	AUT Females - AUT Males	7	0.379	0.062	0.000	[0.257	-	0.501]		2.785	0.835	0.000	− 0.172	0.864
		NT Females - NT Males	5	− 0.182	0.076	0.017	[−0.331	-	− 0.032]		2.532	0.639	0.000	1.078	0.281
		AUT Females - NT Females	5	1.248	0.188	0.000	[0.880	-	1.615]		13.927	0.008	0.697	− 0.151	0.880
		AUT Males - NT Males	5	0.735	0.204	0.000	[0.335	-	1.135]		15.679	0.004	0.726	1.371	0.170
	Total score	AUT Females - AUT Males	11	0.273	0.110	0.013	[0.057	-	0.489]		41.552	0.000	0.711	0.450	0.653
		NT Females - NT Males	6	− 0.077	0.087	0.379	[−0.248	-	0.094]		7.421	0.191	0.203	1.303	0.193
		AUT Females - NT Females	6	1.056	0.244	0.000	[0.578	-	1.533]		28.250	0.000	0.843	− 0.175	0.861
		AUT Males - NT Males	6	0.717	0.173	0.000	[0.379	-	1.056]		16.721	0.005	0.696	2.079	0.037
Discrepancy		AUT Females - AUT Males	4	0.755	0.250	0.003	[0.264	-	1.246]		23.305	0.000	0.773	4.812	0.000

Table 2. Meta-analysis results. REM = Random-effects model; AUT = Autistic individuals; NT = Neurotypical individuals; CAT-Q = Camouflaging Autistic Traits Questionnaire; k = Number of studies included in the analysis; d = Standardized mean difference (pooled); SE = Standard error; CI = Confidence interval; Q = Cochran's statistic; I^2 = Heterogeneity index; Z_{Egger}=Egger's regression test.

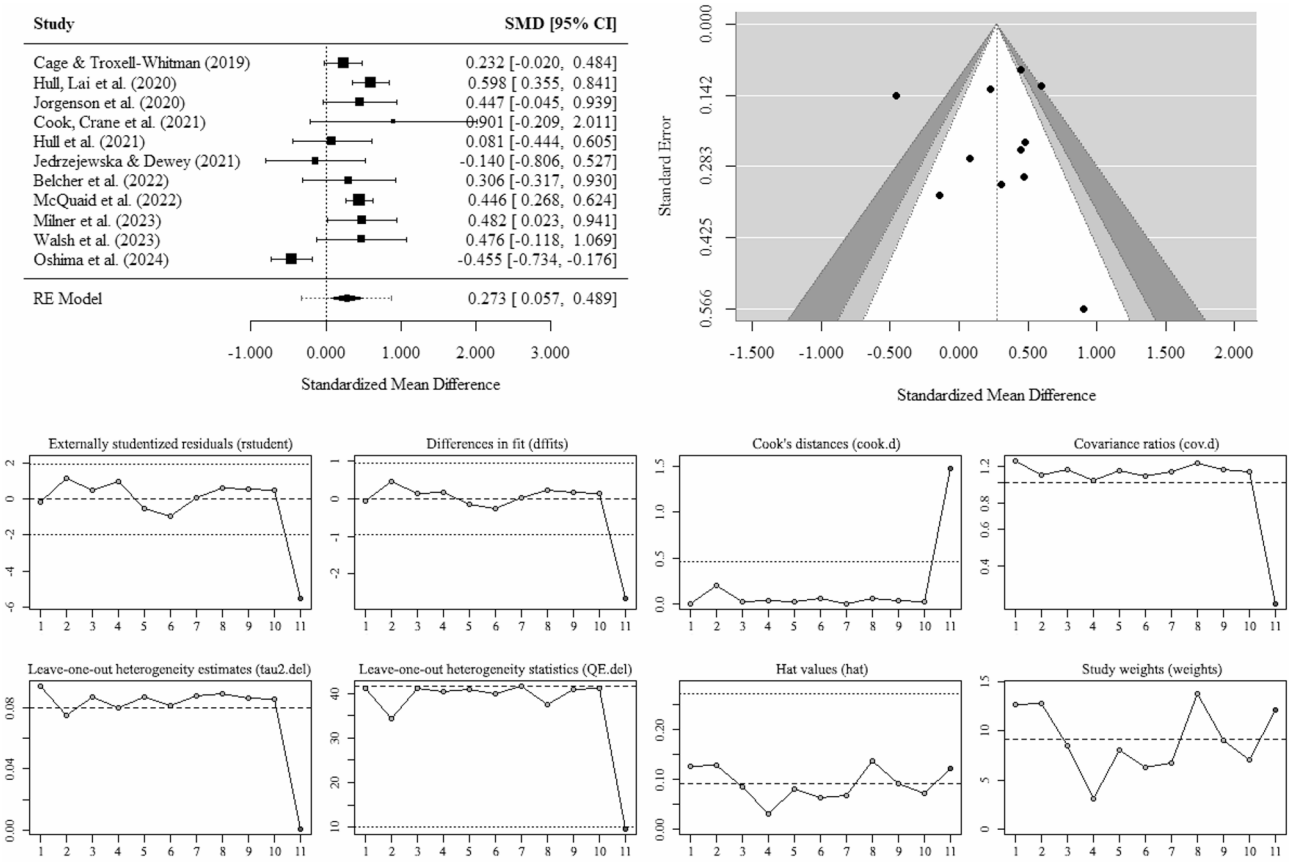

Fig. 2. Forest, funnel and influence plots for the CAT-Q total score (autistic females - autistic males) meta-analysis.

In terms of the CAT-Q, heterogeneity levels for the three main dimensions were particularly high when comparing autistic and neurotypical groups ($pQ \leq 0.046$; $I2 \geq 42.19\%$). For the CAT-Q total score, heterogeneity levels varied from low to high across comparisons ($p_Q \leq 0.191$; $I^2 \geq 20.26\%$). Regarding the discrepancy method, heterogeneity was high for the selected studies ($p_Q = 0.000$; $I^2 = 77.31\%$).

We also conducted Egger's regression test to assess potential publication bias, which evaluates whether the effect sizes are symmetrically distributed around the mean. Any potential publication bias can be detected when scores are statistically far away from the mean. For the CAT-Q, Egger's Z test for asymmetry of the distribution of the effects suggested potential publication bias in the comparisons between autistic and neurotypical males for the Assimilation dimension and the total score ($Z_{Egger} \geq 2.079$; $p \leq .037$). Regarding the discrepancy method, Egger's Z test revealed potential publication bias ($Z_{Egger} = 4.812$; $p = .000$).

Together, these findings underscore the robustness of the main group comparisons, while also suggesting variability in study methods and potential publication bias that should be considered when interpreting the results.

Meta-regression

Meta-regression analysis was conducted to estimate the influence of specific variables on the observed differences between groups. When substantial unexplained heterogeneity exists in the outcomes across studies, it is important to explore whether this variability can be accounted for by study-level characteristics—in this case, the age of participants.

The results of the meta-regression analyses are summarized in Table 3. When examining whether participants' age moderated the previously reported differences in CAT-Q scores between autistic and neurotypical individuals, age did not emerge as a significant moderator for comparisons involving autistic females or autistic males. However, age did appear to play a moderating role in comparisons involving neurotypical individuals, particularly for Assimilation and Masking subscales.

Most notably, age had a consistent and statistically significant moderating effect ($p \leq .005$) in comparisons between autistic and neurotypical females, both for the Assimilation and Masking subscales and for the total CAT-Q score. These findings suggest that the difference in camouflaging behavior between autistic and neurotypical females increases with age. In other words, older autistic females report higher levels of camouflaging than their neurotypical peers, indicating that camouflaging strategies may become more pronounced or more frequently reported with age in this population. A similar age-related pattern was observed among neurotypical males and females for the Assimilation subscale and the total score.

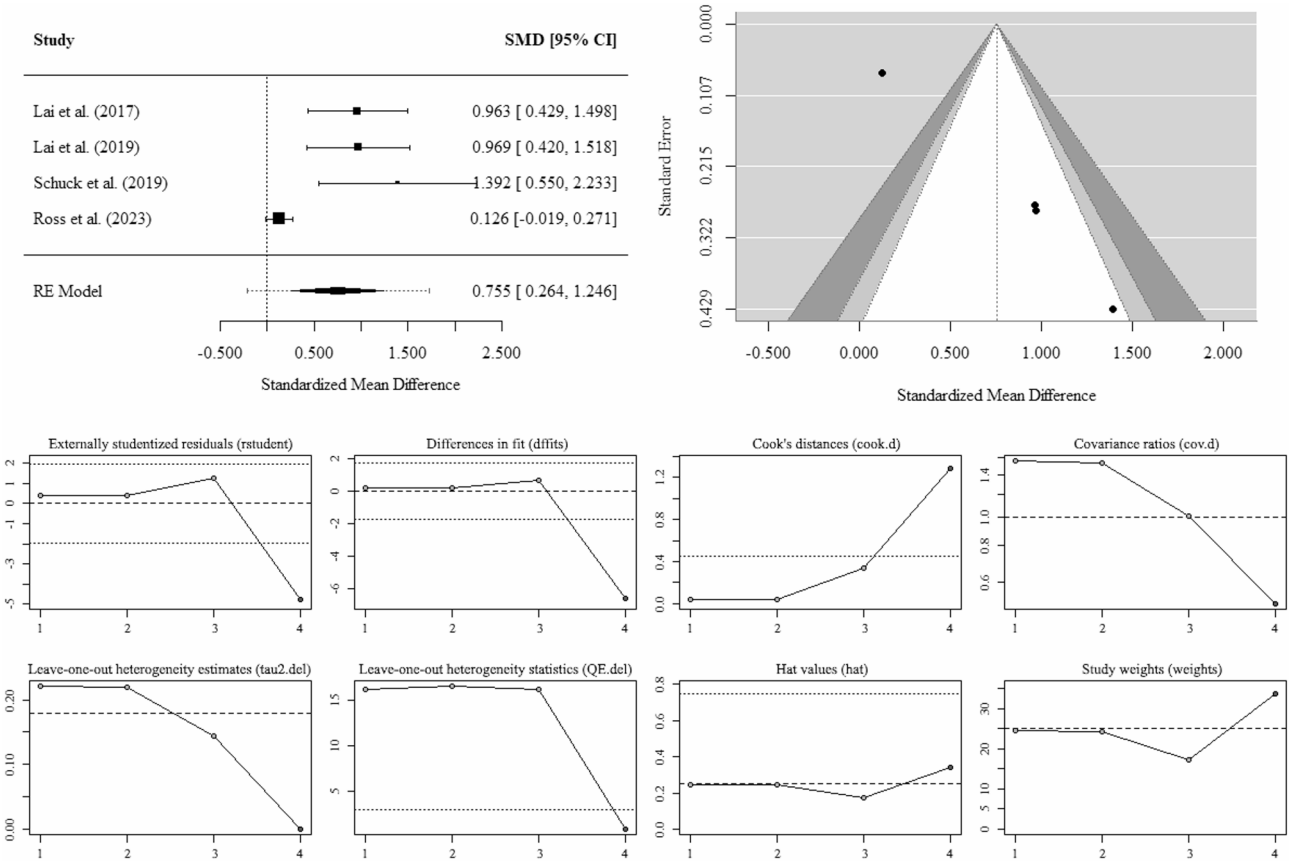

Fig. 3. Forest and funnel plots for the discrepancy method (autistic females - autistic males) meta-analysis.

		MEM						Heterogeneity tests			
		k	Estimate	SE	QM	R^2	*p*	Q	*p*	I^2	$\triangle I^2$
Assimilation	AUT Females - AUT Males	7	0.013	0.009	1.934	0.000	0.164	4.127	0.531	0.000	0.000
	NT Females - NT Males	5	−0.024	0.011	5.070	1.000	0.024	1.268	0.737	0.000	−0.010
	AUT Females - NT Females	5	0.053	0.018	8.334	0.772	0.004	11.096	0.011	0.525	−0.330
	AUT Males - NT Males	5	0.017	0.018	0.919	0.000	0.338	10.064	0.018	0.489	0.067
Masking	AUT Females - AUT Males	7	0.014	0.009	2.425	0.000	0.119	4.061	0.541	0.000	0.000
	NT Females - NT Males	5	−0.016	0.011	2.160	0.000	0.142	0.545	0.909	0.000	0.000
	AUT Females - NT Females	5	0.039	0.014	8.086	0.845	0.005	7.033	0.071	0.324	−0.450
	AUT Males - NT Males	5	0.015	0.015	0.954	0.161	0.329	8.852	0.031	0.434	−0.061
Compensation	AUT Females - AUT Males	7	0.000	0.009	0.002	0.000	0.961	2.782	0.913	0.000	0.000
	NT Females - NT Males	5	−0.016	0.011	2.174	0.000	0.140	0.358	0.949	0.000	0.000
	AUT Females - NT Females	5	0.027	0.017	2.453	0.442	0.117	10.825	0.013	0.534	−0.163
	AUT Males - NT Males	5	0.031	0.017	3.196	0.513	0.074	11.210	0.011	0.535	−0.191
Total score	AUT Females - AUT Males	11	0.004	0.012	0.093	0.000	0.760	41.387	0.000	0.723	−0.034
	NT Females - NT Males	6	−0.020	0.008	6.641	1.000	0.010	0.779	0.941	0.000	−0.203
	AUT Females - NT Females	6	0.050	0.014	12.625	0.837	0.000	10.486	0.000	0.430	−0.413
	AUT Males - NT Males	6	0.028	0.015	3.261	0.338	0.071	14.454	0.006	0.566	−0.130
Discrepancy	AUT Females - AUT Males	4	0.049	0.010	22.591	1.000	0.000	0.714	0.700	0.000	−0.773

Table 3. Meta-regression analysis results. AUT = Autistic individuals; NT = Neurotypical individuals; k = Number of included studies; SE = Standard error; QM = Moderator test; R^2 = Coefficient of determination; Q = Cochran's statistic; I^2 = Heterogeneity index.

When examining the role of participant age in the comparison between autistic males and females using the discrepancy method, results revealed a significant moderating effect (QM = 22.591; R^2 = 1.000; p = .000). The direction of this effect suggests that age amplifies the difference in camouflaging scores—older autistic females exhibit even higher levels of camouflaging compared to autistic males than do younger individuals. These age-related effects accounted for a substantial portion of the observed heterogeneity ($R^2 \geq 0.772$). Additionally, marked reductions in the heterogeneity index were observed, ranging from −1.00% to −44.97% for CAT-Q scores, and reaching −77.31% for the discrepancy-based analysis.

In summary, we conducted a review and examination of 15 studies, carrying out a total of 17 independent meta-analyses to determine differences between males and females, either with autism diagnosis or not. Our analysis included CAT-Q scores from both autistic and neurotypical participants, as well as the discrepancy method. There were significant differences between autistic females and males across all CAT-Q dimensions, with females generally scoring higher on these dimensions. Similar discrepancies were observed when comparing autistic individuals with neurotypical counterparts, particularly in the Assimilation and Compensation dimensions. Notably, heterogeneity was high in autistic -neurotypical group comparisons, suggesting potential publication bias. Overall, autistic females tend to exhibit higher social camouflage tendencies compared to autistic males and neurotypical individuals.

Participants' age did not moderate the effects observed between autistic females and males based on CAT-Q scores. However, age seemed to be a relevant factor when comparing autistic and neurotypical groups and between neurotypical groups, particularly for Assimilation and Masking dimensions. The participant's age had a consistent and significant moderating effect when comparing autistic and neurotypical females. Significant moderating effects of participant age were observed in the comparison between autistic males and females under the discrepancy method, indicating age differences.

Discussion

The current study addressed the most recent studies on camouflage quantification in autistic individuals using two widely employed assessment methods: the discrepancy method, proposed by Lai et al.[22]and the self-report questionnaire CAT-Q by Hull et al.[26]. We aimed to analyze these procedures and compare them by assessing differences in camouflage based on sex (male/female) and diagnostic status (autistic/neurotypical). To our knowledge, this study represents the first meta-analytic approach to synthesize quantitative evidence on camouflage assessment methods and to provide pooled estimates for statistical differences across these groups. Our study follows the line of previous research that compares sex to understand how camouflaging behaviors operate between these two groups. Additionally, when using the CAT-Q, we will extend our analysis to include neurotypical individuals to provide a more comprehensive perspective. Furthermore, this is the first study to estimate the moderating effect of age across a broad age range—from childhood to adulthood—allowing us to explore how camouflaging behaviors may vary across developmental stages.

Among the 15 selected studies, four applied the discrepancy method to assess camouflaging behaviors[22,32,34,35]while eleven articles examined them by using the CAT-Q[25,39,43,56–63]. Of these studies, six established measures of camouflage by sex and diagnosis. Our findings on the discrepancy method revealed statistically significant differences in camouflaging behaviors between autistic males and autistic females, with the latter exhibiting higher scores[22,23,34]. It should be noted that studies employing this method did not use a sample of neurotypical individuals, leaving the question of whether these differences are specific to autistic individuals or are a sex-related phenomenon.

On the other hand, our examination of the quantitative synthesis of the CAT-Q scores allowed us to quantify the differences not only among autistic individuals but also considering neurotypical participants. Our findings reveal an overall statistically significant difference between autistic males and autistic females on the assimilation, masking, and compensation subscales, along with the total scores. This aligns with our results on the discrepancy methods and previous studies suggesting the existence of relevant sex differences, wherein autistic females consistently show higher levels of camouflaging behaviors when compared to autistic males[43,61–63]. In this regard, most studies have proposed that autistic females tend to score higher on the camouflage measure, either because they develop and use camouflage behaviors better than autistic males, or they report it more. It has been suggested that camouflage is strongly linked to a specific phenotype, namely, the Female Autism Phenotype[17,64]. These findings disagree with those obtained by Cruz et al.[64]which found gender differences only in the compensation and masking subscales of the CAT-Q.

In addition, our findings suggest that while some sex differences in camouflaging exist among neurotypicals, these are smaller and less consistent than in autistic individuals. Autistic females consistently scored higher than males, indicating that camouflaging is particularly pronounced within autism. Thus, camouflaging appears to be a sex-specific manifestation in autism rather than a general sex effect.

Our results also confirm that autistic females exhibit significantly higher levels of assimilation and compensation behaviors, and overall camouflage score compared to their neurotypical counterparts, aligning with Belcher et al.[39]Hull, Lai et al.[57]Milner et al.[62]and Walsh et al.[63]. However, these differences are not present in masking behaviors. Similar findings are observed when comparing autistic males with their neurotypical counterparts, exhibiting more assimilation and compensation but not in the masking subscale. When focusing on neurotypical individuals, we observed that males score higher in compensation and masking behaviors than females, but not in assimilation. This suggests that compensation and masking behaviors may not be exclusive to autistic individuals but could also be present among neurotypical males as strategies to enhance perceived social competence. In this context, such behaviors might reflect efforts to conform to social norms or to manage how they are perceived by others, particularly in situations that demand emotional expressiveness or advanced social fluency. While not statistically significant, we observed an interesting tendency where neurotypical males seemed to employ more masking behaviors when compared to their autistic counterparts. This potential finding

has important implications for the broader understanding of camouflaging behaviors in males and females, as it suggests that behaviors such as assimilation, masking, and compensation may be driven by distinct cognitive mechanisms—such as social motivation[81]self-monitoring traits[45]Machiavellian tendencies, and the ability to accurately interpret varying social contexts[72]. This calls for a more comprehensive and nuanced investigation of camouflaging—one that considers not only the observable behaviors, but also the internal and contextual factors that may give rise to them. This includes the specific social settings or interpersonal dynamics in which these behaviors occur, as well as the internal motivations that may drive them, such as emotion regulation, identity management, or the desire to avoid stigma.

However, previous studies using the discrepancy or self-report methods have reported no significant differences between autistic males and autistic females[25,35,39,56–60]. These findings contrast with our current results. Such inconsistencies may reflect methodological variability, differences in sample composition, or limitations in the sensitivity of certain tools to detect subtle sex-related differences in camouflaging. This highlights the importance of using multiple assessment approaches and accounting for potential moderators, such as age and social context, to better capture the complexity of camouflaging behaviors across sexes.

While much of the literature has focused on sex differences in camouflaging behaviors, age also plays a critical role in their emergence and development. In particular, the age at which an individual receives an autism diagnosis may influence both the onset and the trajectory of camouflaging. For example, McQuaid et al.[61] found that individuals diagnosed in adulthood reported higher levels of assimilation and compensation compared to those diagnosed in childhood or adolescence. These findings suggest that a later diagnosis may be associated with the emergence or intensification of camouflaging behaviors over time. This underscores the importance of considering not only sex differences but also developmental and diagnostic timing when investigating camouflaging. Moreover, while factors such as age, time since diagnosis, co-occurring conditions, and personality traits may influence these behavioral patterns, the limited sensitivity and specificity of current assessment tools constrain our ability to capture these nuances fully.

Our results regarding the moderating role of the participants' age in the observed effects for the CAT-Q-based meta-analysis, showed that, when statistically significant, this variable seems to explain a high amount of between-study heterogeneity ($R^2 = 0.772$ to 1.000; $\triangle I^2 = -20.15$ to -44.97%). This is particularly noticeable when examining its role in the comparisons including neurotypical groups. These results suggest that as individuals age, sex differences in the tendency to engage in assimilation and masking behaviors may become more pronounced. A later diagnosis has been associated with greater camouflaging and distinct behavioral adaptations over time which may reflect increasing social and cultural pressures across the lifespan. This trend could also be attributed to improved social awareness and a heightened need to adapt to diverse social environments—particularly among autistic females in adolescence and adulthood[48,72]. In contrast, the absence of age-related differences in compensatory behaviors suggests that strategies such as rehearsing social interactions or pre-planning conversation topics may be consistently used across different age groups.

Regarding its moderating role in the discrepancy method-based meta-analysis, we observed that age accounted for most of the heterogeneity ($R^2 = 1.000$; $\triangle I^2 = -77.31\%$) and had a significant moderating effect. Based on this, age seems to play an important role in the perceived discrepancies between internal status and external behaviors, suggesting that there might be a developmental component in the camouflaging behaviors employed by autistic individuals that varies across different age groups. However, while these results are interesting, the generalizability of these findings is restricted due to the small number of studies included ($k = 4$) and must be interpreted with caution. In addition, it is necessary to establish differential standards in the assessment of camouflaging in children because the instruments analyzed in this paper are not entirely suitable for this population. Other methods need to be developed to precisely quantify these behaviors, considering developmental and contextual aspects. It has recently been developed the Parent-report version of The Camouflaging Autistic Traits Questionnaire[65] that could be useful for this purpose.

One of the most prominent limitations of the discrepancy method lies in the inconsistency of procedures used to assess individuals' internal states. While all studies rely on the ADOS to measure external behavior, the tools used to evaluate internal experiences vary considerably. For example, Lai et al.[22,32] employed the RMET and AQ; Schuck et al.[34]used only the AQ; and Ross et al.[35] relied on the SRS-parent.

Beyond this variability, concerns have also been raised about the validity of the instruments themselves. The AQ, for instance, has been found to exhibit gender bias, potentially limiting its sensitivity to autistic traits in females and other underrepresented populations (Belcher et al., 2023). The RMET often fails to differentiate between autistic and non-autistic adults, casting doubt on its utility in assessing internal social-cognitive differences.

Furthermore, the discrepancy method assumes that divergences between internal and external measures directly reflect camouflaging. However, such discrepancies may also result from a range of other factors, including measurement limitations, differences in self-awareness, alexithymia, or broader contextual and individual influences. As such, interpretations based solely on this method should be treated with caution and ideally supported by complementary assessment tools and theoretical frameworks.

This highlights that no established criteria exist to determine the best or most suitable procedures or tools for measuring internal status[26]. Although the discrepancy method seeks to capture relevant aspects considered in camouflage, such as imitation of social skills, cognitive aspects, and behavioral skills, this method does not allow identifying specific camouflaging behaviors, considering the variability among studies to estimate internal status[22,26].

A potential way to distinguish which procedures are the most suitable for this purpose would be to estimate the overall reliability of the final camouflage score based on temporal stability (i.e., test-retest evaluations). If, when tested, participants obtain similar consistent scores across different evaluations, we could feel more confident about that particular procedure[65]. So far, this has not yet been done in the context of the assessment

of camouflaging behaviors. Additionally, Hull et al.[17] have questioned whether these methods can truly evaluate internal autistic characteristics. This criticism not only points to the lack of consensus on using different procedures to measure internal status but also the lack of validity of said procedures. Nevertheless, although there is consensus that ADOS can be used to assess external behaviors, this measure is not sensitive for autistic females[3,66,67]. Due to this, autistic females may go underdiagnosed, and their level of autism may not be correctly quantified.

Thus, relying on either or both of these methods to measure camouflage behaviors is risky because the criticisms we have outlined for the discrepancy method question the validity of the 'internal status' construct; and that the use of traditional diagnostic criteria to measure autism makes it less likely to detect autistic females. Concerning the CAT-Q, as with other self-report measures, its accuracy may depend on the respondent's level of self-awareness. Because some camouflaging behaviors may operate outside of conscious awareness, individuals might unintentionally overestimate or underestimate their engagement in such behaviors, potentially limiting the precision of self-reported data.

Regarding self-report measurement tools, the CAT-Q is the most specific questionnaire for measuring camouflage strategies, showing robust psychometric support[26]. In contrast to the other quaternaries, The CAT-Q is the only method with an estimate of test-retest reliability[65]. While there are other questionnaires such as the GQ-ASC[37]the CATI[36] and the Cassidy Questionnaire[38]these have the drawback of lacking specificity in measuring camouflage. For this reason, the CAT-Q was the only questionnaire employed in this meta-analysis as it has the advantage of being a self-report measure focused on quantifying camouflaging behaviors through self-reflection[26,68]. However, it carries the disadvantage that it relies on individuals' self-perception and has a risk of overestimating or underestimating camouflaging behaviors and precise clinical criteria for quantifying adaptive behaviors. It should be noted that in the last few years, new questionnaires derived from CAT-Q have been developed, such as the aforementioned. The Parent-report version of The Camouflaging Autistic Traits Questionnaire[65]The Camouflaging Autistic Traits Online Questionnaire (CATO-Q)[60]and The Camouflaging Autistic Traits Questionnaire short form (CATQ-SF)[69]. However, studies have yet to employ them because they are recent publications. The relevance of these new questionnaires needs to be analyzed in the future.

An aspect derived from the literature used in this meta-analysis indicates that camouflage behaviors improve social performance in autistic individuals. This is particularly notorious in females, who are generally perceived as more socially competent than males. This has been observed in the quality of friendships, empathy, perception of others, and social reciprocity[14,23,57,70]. Autistic females are often more aware of social difficulties and the need for social relationships[48]. In addition, autistic females have superior language skills, observable in communicative gestures[71]interjections[72]and vocal expressiveness[73]. Nevertheless, compared to their neurotypical peers, autistic females tend to perform less in social and communicative behaviors[74,75]. However, the effectiveness of camouflaging remains uncertain, as most evidence relies on self-reported efforts rather than objective indicators of social success. Research using first-impression paradigms has shown that camouflaging does not necessarily lead to more favorable social evaluations by neurotypical individuals[57]. From a broader social perspective, camouflaging may be understood as a form of impression management common to all individuals. However, autistic individuals, particularly females, may need to exert greater cognitive and emotional effort to achieve comparable social outcomes. This heightened effort and self-monitoring can lead to psychological strain, suggesting that camouflaging is not merely an adaptive strategy but also a potentially costly one, particularly when it is sustained over time or fails to yield social rewards.

A significant concern—both in the present meta-analysis and in the broader literature—is the lack of diversity in participant samples. Most included studies focus exclusively on individuals who identify as male or female, thereby excluding non-binary and gender-diverse individuals. This omission is particularly problematic given that a higher proportion of autistic people tend to identify outside the gender binary. Additionally, the vast majority of participants across studies are white, with minimal representation from ethnic and racial minority groups. This lack of inclusivity limits the generalizability of findings and perpetuates systemic barriers to the diagnosis and recognition of autism in marginalized communities. To more accurately reflect the diversity of autistic experiences, future research must prioritize demographic representation, particularly among those who are most often underrepresented and underserved.

Even though camouflage behaviors could have certain benefits in social adaptation, they are not entirely adaptive, as evidence has also shown mental health-related negative outcomes in autistic individuals. There is a proposition suggesting that autistic females, due to a more adaptive social presentation and potential biases related to gender, may be less likely to meet diagnostic criteria compared to males[11]. Besides, camouflaging might predict anxiety, stress, and depressive symptoms, along with somatic complaints and reduced adaptive functioning in adulthood[35,55,76,77]. These issues significantly impact general well-being, causing difficulties such as achieving financial independence, dealing with mental health issues, and maintaining friendships[78]. In addition, research on autistic females has highlighted an association between autistic traits and lifetime suicidality significantly moderated by camouflaging behaviors[77,79]. Thus, improving diagnostic accuracy while also preventing severe symptomatology, such as suicidal ideation or suicide risk, is critical. Our approach could be used for further research into camouflaging behaviors considering these four groups (autistic and neurotypical females and males), as well as the moderating effect of age.

Limitations

Our meta-analysis has several limitations that warrant acknowledgment. First, although we included 15 studies, the overall sample lacked diversity in key demographic variables. Most notably, information regarding participants' racial, ethnic, and socioeconomic backgrounds was either missing or inconsistently reported, limiting the generalizability of our findings. Moreover, although comparisons between autistic females and

males were relatively consistent, neurotypical groups were underrepresented across several studies, particularly in analyses based on the discrepancy method.

Another important limitation concerns the heterogeneity in participant age across studies. Although this allowed us to examine potential developmental effects, we were unable to account for the age at which participants received their autism diagnosis. This is a crucial factor, as prior research has shown that individuals diagnosed in adulthood may exhibit different camouflaging behaviors compared to those diagnosed earlier in life. Thus, while our meta-regression revealed age-related moderation effects, particularly among females, these findings should be interpreted with caution, given the lack of diagnostic age data.

Furthermore, we were limited by the availability and consistency of reported data. Many studies did not disaggregate CAT-Q scores by subscales, restricting our ability to examine whether certain camouflaging strategies (e.g., masking vs. compensation) are more strongly associated with particular variables or groups. Likewise, few studies used the discrepancy method with neurotypical participants, limiting our capacity to assess the role of diagnostic status in camouflaging behaviors.

Lastly, given the variability across studies—both in the populations examined (autistic-only vs. autistic and neurotypical) and in sample characteristics (e.g., age, ethnicity, age at diagnosis)—we addressed only a portion of this heterogeneity, specifically participant age, through meta-regression. Therefore, the present findings should be considered preliminary and highlight the need for replication in future studies with more rigorously characterized and demographically diverse samples.

Conclusion

The principal conclusion drawn from the results is that there are statistically significant differences between autistic females and autistic males in camouflaging behaviors, with females generally exhibiting higher CAT-Q scores across all three subscales, assimilation, masking, and compensation. Furthermore, when comparing autistic and neurotypical individuals, the first one tends to show higher scores in assimilation and compensation behaviors. However, no significant differences were observed in the masking subscale when comparing autistic with neurotypical groups. Additionally, the discrepancy method analysis suggests that autistic females tend to have higher camouflage scores than autistic males. However, heterogeneity levels were notably high when comparing autistic with neurotypical groups, indicating variability across studies. Egger's Z test suggested potential publication bias in some comparisons.

Moreover, age emerges as a significant moderating factor in the comparisons between autistic and neurotypical groups, especially regarding assimilation and masking behaviors, with age consistently impacting the CAT-Q scores of autistic females. Additionally, age significantly moderates the comparison between autistic males and females using the discrepancy method. Overall, these findings indicate the importance of considering gender differences and age effects when assessing camouflaging behaviors in autistic individuals.

Overall, camouflage is a distinctive yet complex phenomenon that requires deeper understanding, especially given its potentially adverse implications. There is a growing and notorious need for objective and reliable assessment methods to evaluate and detect them, aiming to mitigate the negative consequences of late or inaccurate diagnosis. It is also important to consider that camouflaging may not be confined to a binary categorization, such as male or female, or to one's assigned sex at birth. Future research should examine autism phenotypes and camouflaging behaviors in individuals across the spectrum of gender identities, including non-binary, transgender, and other gender-diverse populations, who remain largely underrepresented in the literature. Future studies should continue providing information on the key differences between females and males in terms of the expression of these behaviors and of autistic traits in general, but also to consider potentially relevant factors like age range, education level, socio-economic status or cultural context.

Data availability

All data used in this meta-analysis were extracted from publicly available publications listed in the references. No new data were generated for this study.

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Author contributions

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Declarations

Competing interests
The authors declare that they have no conflicts of interest to disclose.

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