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The dimensional structure of the Camouflaging Autistic Traits Questionnaire (CAT-Q) and predictors of camouflaging in a representative general population sample

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ABSTRACT

Objectives: Some autistic people "camouflage" their differences by modeling neurotypical behaviors to survive in a neurotypical-dominant social world. It remains elusive whether camouflaging is unique to autism or if it entails similar experiences across human groups as part of ubiquitous impression management (IM). Here we examined camouflaging engagement and theoretical drivers in the general population, drawing on the transactional IM framework and contextualizing findings within both contemporary autism research and the past IM literature.

Methods: A large representative U.S. general population sample ($N = 972$) completed this survey study. We combined exploratory item factor analysis and graph analysis to triangulate the dimensional structure of the Camouflaging Autistic Traits Questionnaire (CAT-Q) and examined its correspondence with prior autism-enriched psychometric findings. We then employed hierarchical regression and elastic-net regression to identify the predictors of camouflaging, including demographic (e.g., age, gender), neurodivergence (i.e., autistic and ADHD traits), socio-motivational, and cognitive factors.

Results: We found a three-factor/dimensional structure of the CAT-Q in the general population, nearly identical to that found in previous autism-enriched samples. Significant socio-motivational predictors of camouflaging included greater social comparison, greater public self-consciousness, greater internalized social stigma, and greater social anxiety. These camouflaging drivers overlap with findings in recent autistic camouflaging studies and prior IM research.

Conclusions: The novel psychometric and socio-motivational evidence demonstrates camouflaging as a shared social coping experience across the general population, including autistic people. This continuity guides a clearer understanding of camouflaging and has key implications for autism scholars, clinicians, and the broader clinical intersecting with social psychology research. Future research areas are mapped to elucidate how camouflaging/IM manifests and functions within person-environment transactions across social-identity and clinical groups.

1. Introduction

Some autistic people employ behavioral strategies, known as "camouflaging," to minimize the visibility of their autism in social contexts. These behaviors include, for example, deliberately maintaining eye contact, mimicking others' speech patterns and body language, and memorizing conversation scripts [1,2]. For some autistic individuals, camouflaging entails enacting a socially accepted persona [3,4] to survive in a neurotypical world [5]. Despite growing research, a precise and comprehensive conceptualization of camouflaging remains elusive [6–8]. One key question is whether camouflaging is an exclusive experience in autistic people, or if it is a common phenomenon presenting continuously across the general population, as part of the ubiquitous impression management (IM) experiences [9]. Conceptual and empirical clarifications are needed to accurately interpret the rapidly growing findings in autistic and non-autistic people [1,2], and

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guide more precise research directions on the mechanisms and psychiatric implications of camouflaging and/or IM.

IM refers to the regulation of social information to convey favorable impressions of oneself in others [10,11], encompassing constructs such as self-presentation [12]. Drawing from computational, social, and clinical psychology research, we have recently proposed a transactional framework model that demonstrates how IM is conceptually inclusive of camouflaging, and theorized the potential mechanistic relations between camouflaging/IM and socio-motivational, neurocognitive, and mental health factors [9]. However, IM can also involve some unique transactional features when considering the interaction between autistic cognition and neurotypical social contexts; differences in autistic social beliefs, needs, and information processing might prompt a reciprocal social misunderstanding, which then demand more effortful, pervasive, and psychologically costly camouflaging/IM. To evaluate this new framework empirically, it is important to (a) psychometrically assess measures of autistic camouflaging in the general population to see whether their factor/dimensional structures correspond to findings in autistic populations, and (b) examine whether the demographic, socio-motivational, and cognitive correlates of camouflaging map onto established IM research findings. This pincer exploration would fill critical knowledge gaps by bringing together past IM research [11] and new insights on camouflaging from autism-enriched studies [1].

To achieve the first goal, the Camouflaging Autistic Traits Questionnaire (CAT-Q) [13] serves as a key measure to assess the extent to which camouflaging experiences overlap across diverse human groups. This self-report measure was developed from qualitative research on autistic camouflaging experiences [14] and validated with both autistic (N = 354) and non-autistic (N = 478) adults for cross-diagnosis application [13]. The CAT-Q measures compensatory strategies, ways to mask one's autistic features, and intentions to fit in in social situations. It is widely used in autism research with several cross-cultural translations and replications [15–19]. So far, no research has evaluated the structure of the CAT-Q in a representative general population sample. This approach can unveil the continuity and dimensionality of camouflaging experiences in the general population. Hence, rather than to validate the CAT-Q for a specific sub-population, we employed advanced exploratory factor-analytic and network-based analyses to examine the dimensional structure of the CAT-Q across diverse individuals in the general population. This is a novel examination that is central to the conceptualization of camouflaging as IM [9], moving beyond the yet limited measurement invariance findings across autistic and non-autistic individuals [13,19].

Regarding the second goal, the transactional IM framework highlights how different demographic, socio-motivational, and cognitive factors can influence one's camouflaging/IM experiences [9]. Demographically, a general population study can unveil how variations in sex, gender identity, sexual orientation, ethnicity, and neurodivergent traits may modulate camouflaging/IM tendencies. For example, autistic women have been found to engage more in camouflaging than autistic men [1], implying gender effects at least in the autistic population. The concealment of different social identities (e.g., sexual orientation) has been found as well in IM research [20], implicating continuity of camouflaging/IM needs across social groups. Camouflaging as social coping experiences in other neurodivergent people (e.g., ADHD) has also been speculated [9,21].

Our model hypothesizes that the socio-motivational "drivers" of camouflaging overlap with those of IM [9]. Past research suggests that IM constructs such as self-presentation and self-concealment are driven by needs to mitigate social exclusion [22], maintain self-esteem [23], avoid social stigma [20], and secure social belongingness and approval [11,24,25]. These interpersonal motivations are echoed by those of camouflaging as described by autistic people, including needs for social contact [1,2], mitigating internalized and perceived autism-associated stigma [26,27], and avoiding negative perceptions and marginalization [5].

Although more research is required to identify the cognitive capacities that support camouflaging [28], existing findings indicate similar cognitive foundations of camouflaging and IM. Notably, executive function has been linked with camouflaging in autistic people [28–30] and IM across the general population [31,32]. Greater executive function might enable self-monitoring, attention shifting to social cues, behavioral inhibition to reduce socially undesirable acts, and flexibility in and planning for displaying contextually adaptive behavioral responses [9]. Additionally, emotion regulation, the modulation of emotional expressions in accordance with contextual social standards, might facilitate "surface acting" in emotion labor during IM [33,34] and likely also camouflaging. Finally, camouflaging and IM require an awareness of the self as a social object under public scrutiny, making perspective taking essential in enabling one to infer the expected or optimal impression to enact within an interaction [28,35].

Building on the transactional IM framework linking camouflaging to IM, we used a representative general population sample to address two linked research aims via a two-part investigation. First, we examined the dimensional structure and item properties of the CAT-Q using novel factor-analytic and network-based psychometric analyses. Findings were integrated to triangulate the CAT-Q's dimensional structure, generate insights into item importance and interconnections [36], and compare the derived CAT-Q structure with the existing literature. Following this, we identified the demographic predictors of camouflaging using hierarchical regression, as well as the most important, theory-driven socio-motivational and cognitive predictors of camouflaging using regularized elastic-net regression. We evaluated whether findings echo what was learned in both autistic people and the IM literature at large. Implications are discussed to identify future research avenues to understand social coping and mental well-being across the population, including autistic and other neurodivergent individuals.

2. Methods overview

2.1. Participants

The participants consisted of 1051 adults aged 18 years and above who can self-report and provide consent. Our determined sample size was the largest we could opt for given study feasibility. The target sample size aligns with the recommended sample size of 1000 for accurate parameter estimations using multidimensional item factor analyses [37]. There is no formal guideline on sample size requirements for network-based analyses given that the optimally powered sample size depends on multiple factors such as the true edge weights, item variance, and node numbers. However, our sample size is consistent with simulation-based recommendations using this technique [38,39]. Recruitment was conducted over the course of 26 days via the *Prolific* platform, an online crowdsourcing portal that enables individual users to volunteer for and complete web-based studies for monetary compensation (i.e., all participants were *Prolific* users). Participants were compensated USD $9.50/h and recruited using U.S. national general population representative sampling. This is a sampling algorithm service provided by *Prolific* using the U.S. census data [40], stratified across demographic variables including age, ethnicity, and sex. Five participants were excluded from the analyses due to misreporting in age (i.e., over 400 years) or failed attention checks, and 74 participants were excluded due to missing item-level data. The final sample consisted of complete item-level data from 972 participants that were retained for data analyses in this study. The sample comprised 461 men (self-identified cisgender men), 491 women (self-identified cisgender women), 20 gender-diverse individuals, with a mean age of 44.2 year (range 18–90 years, median 43.0 year), 72.7% identified as Caucasian, and 7.51% identified as neurodivergent (see Table 1 for full demographics information).

Table 1
Sample demographic characteristics.

	N	%
Gender		
Men (also referred to as cisgender men)	461	47.4
Women (also referred to as cisgender women)	491	50.5
Gender-diverse	20	2.06
Sex assigned at birth		
Male	469	48.3
Female	503	51.8
Ethnicity		
Caucasian	707	72.7
Black or African American	131	13.5
Asian	72	7.41
American or Alaskan Native	9	0.93
Native Hawaiian or Pacific Islander	3	0.31
Prefer not to answer	3	0.31
Other (e.g., Mixed, Hispanic)	47	5.14
Sexual orientation		
Heterosexual	809	83.2
Bisexual	77	7.92
Gay	22	2.26
Lesbian	17	1.75
Pansexual	14	1.44
Not sure or questioning	8	0.82
Queer	7	0.72
Asexual	6	0.62
Two-spirit	2	0.21
Prefer not to say	5	0.51
Other (e.g., Demisexual)	5	0.51
Self-reported clinical diagnosis		
None	516	53.1
Mental health diagnoses (e.g., anxiety, depression, bipolar disorder)	124	12.8
Chronic medical conditions	91	9.36
Neurodivergent	19	1.96
Substance use disorder	6	0.62
Multi-diagnostic categories	183	18.8
Do not know	16	1.65
Prefer not to answer	11	1.13
Other (e.g., sensory perception disorder)	6	0.62
Education level		
University/college diploma	371	38.2
High school diploma	290	29.8
Master's degree	224	23.1
Doctoral degree or equivalent	44	4.53
Middle school degree	3	0.31
Primary school degree	2	0.21
Other (e.g., Trade, Associate degree)	38	3.91
	M	***SD***
Age (years)	44.2	16.3
Education years	15.9	3.84

Note. Gender-diverse individuals include trans men, trans women, genderqueer, genderfluid, androgynous, nonbinary, or prefer not to answer. Mental health diagnoses were ascertained via self-report. Chronic medical conditions include health condition that lasts for a long time, such as diabetes, asthma, epilepsy, cerebral palsy, or sensory disability. The neurodivergent category includes individuals reporting being diagnosed with autism, ADHD, or learning disability. The multi-diagnostic categories group includes individuals reporting being diagnosed with multiple diagnostic categories and are exclusive to the rest of individuals reporting only a single diagnostic category.

2.2. Procedures and measures

Participants completed a web-based survey on the *Qualtrics* platform with an average completion time of 54 min. The survey consisted of a demographic questionnaire (Table 1) and a battery of self-report measures assessing neurodivergent traits, socio-motivational and cognitive constructs. These measures were selected based on applicability to an online survey format, brevity, psychometric rigor, and theoretical relevance to key constructs outlined in the transactional IM framework [9] (see Supplemental Materials for details and psychometrics information for each measure). For data quality assurance, Prolific employs ubiquitous fraud detection procedures through stringent sign-up verifications and monitoring for unusual user patterns (https://www.prolific.com/blog/bots-and-data-quality-on-crowdsourcing-platforms). For this study specifically, two attention check questions were included to enhance the data integrity of online data collection. We also only retained complete item-level responses as part of the quality check procedure.

The CAT-Q [13] was used to measure camouflaging, and the Self-Presentation Tactics scale (SPT) [41] was used to measure self-presentation tendencies. Self-presentation entails strategic actions aimed at constructing a more positive or advantageous public image, involving assertive tactics such as self-promotion and defensive tactics such as disclaimers and justifications. We focus on self-presentation to approximate IM because the construct is well-established, conceptualized as an intrinsic component of IM, and has been widely studied in the general population [11]. The Subthreshold Autism Trait Questionnaire (SATQ) [42] and the Adult ADHD Self-Report Scale Part A (ASRS-A) [43] were included to measure autistic and ADHD traits, respectively.

The transactional IM framework [9] proposes that the mitigation of stigma and the needs for social belonging and acceptance are key socio-motivational themes that prompt camouflaging/IM. It also posits that engagement in camouflaging/IM requires an understanding of the self as under social scrutiny with interpersonal needs. In the current study, measures of key socio-motivational constructs that are theoretically relevant to the framework included the Inclusion of Other in the Self Scale (IOS) [44] to measure social closeness, Self-Consciousness Scale (SelfCon) Public subscale [45] to measure public self-consciousness, Iowa-Netherlands Comparison Orientation Measure (INCOM) [46] to measure social comparison tendencies, the Interpersonal Needs Questionnaire (INQ) [47] Thwarted Belongingness subscale to measure social belonging, Internalized Stigma of Mental Illness Inventory 10-item version (ISMI-10) [48] to measure perceived and internalized social stigma, Relational Self-Esteem Scale (RSE) [49] to measure relational self-esteem, Perceived Social Competence Scale (PSCS) [50] to measure self-reported social competence, and the Liebowitz Social Anxiety Scale (LSAS) [51] to measure social anxiety and avoidance.

The measurements for supportive cognitive skills highlighted by the transactional IM framework included: the Amsterdam Executive Functions Inventory (AEFI) [52] to measure general executive functions, the Cognitive Flexibility Scale (CFS) [53] to measure cognitive flexibility, the Interpersonal Reactivity Inventory (IRI) [54] as an index of perspective taking skills, the Behavioral Inhibition Scale Brief Version (BIS-BRIEF) [55] to measure inhibition skills, and the Emotion Regulation Questionnaire (ERQ) [56] to measure emotion regulation capacities.

The data collected in this project are being analyzed for ongoing studies and will be made publicly available once these planned analyses are complete. The complete analysis code scripts are available from the corresponding author on request. The study design, procedure, and measures were approved by the Research Ethics Board at the Centre for Addiction and Mental Health (CAMH), Toronto, Canada (REB # 079/2021).

2.3. Statistical analyses overview

There were no missing item-level data for any of the analyses performed. Following the two aims, two sets of analyses (see Sections 3 and 4 below, respectively) were conducted sequentially using the same complete item-level dataset of 972 participants. Considering brevity and theoretical relevance, we used the subscale scores for specific measures, including the Perspective Taking subscale of the IRI, the Public subscale of the SelfCon, and the Thwarted Belongingness subscale of the INQ. For the LSAS, we used the total subscale scores for the Social Anxiety and Social Avoidance subscales separately. For all other measures, total scale scores were used.

In the first set of analyses, we examined the dimensional structure of the CAT-Q using both an exploratory item factor analysis (EIFA) [57] and an exploratory graph analysis (EGA) [58], followed by assessing the correlations between CAT-Q and SPT total scale scores to determine convergent validity. In the second set of analyses, we examined the demographic characteristics, neurodivergent traits, and socio-motivational and cognitive factors most associated with the CAT-Q. Here, we used hierarchical regression to assess the predictive effects of ADHD and autistic traits on camouflaging over and above demographic variables. Then, we used regularized regression models to identify the most important socio-motivational and cognitive predictors of CAT-Q scores beyond the effects of neurodivergent trait variables. The total or subscale scores corresponding to the relevant predictor constructs were used for the regression analysis. It is important to note that although these variables were treated as predictors in the regression models, the cross-sectional nature of our data means that the current set of analyses cannot establish directionality or causality of the effects. All analyses were performed in R version 4.2.1 [59].

3. Analysis 1: What is the dimensional structure of the CAT-Q in the general population?

3.1. Method: Exploratory item factor analysis and exploratory graph analysis

We used both EIFA and EGA to estimate the CAT-Q's dimensional structure. These two methods provide synergistic information to corroborate factor-analytic and network-based interpretations. Both EIFA and EGA are data-driven and exploratory in nature, ideal for eliciting new insights given the limited knowledge of the psychometric properties of the CAT-Q in the general population. To examine the convergence of findings, we used the *sort* function in base R to randomly divided the complete dataset into two independent sub-samples (no match factors included) for performing each analysis. The two split-half samples did not differ significantly in CAT-Q scores, age, sex assigned at birth, gender, or ethnicity proportions (see Supplemental Materials).

Different from exploratory and confirmatory factor analyses for factor extraction, EIFA is not as restrictive in the treatment of factor cross-loadings as conventional approaches under classical test theory [57]. Instead, EIFA extends item response theory into a multidimensional latent space to hypothesize the probability of associations between scale item responses and latent dimensions. The non-linear and data-driven approach of the EIFA is fitting for multidimensional Likert-scale data (e.g., the CAT-Q), particularly when the underlying factors may be correlated [60]. This technique is progressively applied across multiple fields of psychological science [61–64].

In the EIFA subsample ($N = 486$), following the K1 rule, a scree plot suggests that a 3- or 4-factor model would show optimal fit. Using the *mirt* package [57], a series of EIFA models (from 1 to 4 factors) were estimated to assess solutions with different factor numbers. The solutions were then evaluated using three fit indices [65], including root-mean-square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean square residual (SRMR). Additionally, the models were assessed on the number of cross-loadings, strength of factor loadings, and whether the factor composition makes conceptual sense. Model fit indices were estimated using the Metropolis-Hastings Robbins-Monro (MH-RM) algorithm and quasi-Monte Carlo integration. The oblimin (i.e., oblique) rotation method was applied to allow factor correlations during factor loading and coefficient extraction [57,66]. Model comparisons were conducted with χ^2 likelihood ratio tests.

Thereafter, using the EGA subsample ($N = 486$), we employed EGA as an alternative, graph theory-based examination of the dimensional structure of CAT-Q in the general population. Graph/network-based analysis estimates item-level network loadings that are roughly equivalent to factor loadings in a factor analysis [67] and performs as accurately as conventional factor models [68]. EGA differs from factor analysis as it does not assume causal latent factors; instead, this method views constructs as emergent properties of complex interactions among component elements, which cluster together as they influence each other. EGA regularizes a scale's network structure by calculating several networks with varied lambda values in controlling sparsity. This technique has been successfully employed to evaluate the structure of instruments with multiple correlated latent dimensions [68].

For CAT-Q responses, an undirected and weighted network derived from partial correlations was estimated with the EBICglasso function (i.e., graphical lasso using extended Bayesian Information Criterion) using the *bootnet* package [38]. The function selects a regularization tuning parameter that optimizes the sparsity of the CAT-Q item network structure. First, estimates of network-level (e.g., the number of dimensions, network stability) and item-level (e.g., network loadings, item centrality metrics) metrics were calculated via bootstrapping the network model for 1000 iterations. Second, item communities within the CAT-Q network were identified via the fast greedy community detection algorithm, which iteratively resamples subnetworks in the model to optimize modularity score [69]. The modularity score provides an index (values ranging from −1 to 1) of the extent of connecting nodes within a community compared with that outside the community. A modularity score of 1 suggests that all edges reflect connecting nodes within a community. Altogether, the EGA allows us to look for the dimensional/community structure of the CAT-Q and to identify nodes/items with high importance as indicated by their centrality.

After delineating the CAT-Q's dimensional structure, convergent validity was assessed by examining the Pearson's correlation between CAT-Q and SPT scores using the full sample.

3.2. Results of analysis 1

In the EIFA subsample, EIFA produced acceptable model fit indices for the 3-factor (RMSEA = 0.058, SRMR = 0.062, CFI = 0.942) and 4-factor models (RMSEA = 0.047, SRMR = 0.046, CFI = 0.969) of the CAT-Q. Although the χ^2 likelihood ratio test (evaluating the AIC and BIC metrics) and the three fit indices chosen a priori suggest that the 4-factor solution fits significantly better than the 3-factor solution, closer examination suggests that none of the items loaded saliently onto the additionally estimated factor in the 4-factor model (i.e., all factor loadings were below 0.38). Further, for this fourth factor, items with relatively higher loadings do not appear to make conceptual sense when considered together as a factor; hence, the items were considered poor measurements of this additional factor. Conversely, the item composition of the 3-factor model (Table 2) is more parsimonious, has acceptable model-fit, yields no complex loadings, is more interpretable, and largely reflects the item distribution of the original CAT-Q structure developed with autism-enriched samples. Hence, we determined that the 3-factor model provides a more reasonable fit.

In the 3-factor model, Factor 1 (analogous to the original Compensation subscale of the CAT-Q) was saliently loaded by 9 items characterizing deliberate, preparatory, and externally informed (e.g., from media, peer observations) strategies. Factor 2 (analogous to the Masking subscale of the CAT-Q) was saliently loaded by 6 items characterizing introspective strategies for the adjustment or monitoring of body and facial expressions. Lastly, Factor 3 (analogous to the Assimilation subscale of the CAT-Q) was saliently loaded by 8 items characterizing the social motivations of camouflaging and appraisals of interactions. Items 12 and 24 (originally belonging to the Masking subscale) did not load saliently onto any of the factors. Given the substantial overlap in item distribution and conceptual interpretations, the 3 factors extracted from EIFA were labeled with the original subscale names of the CAT-Q. Internal consistency was excellent across the Compensation (α = 0.92 [95% CI 0.91, 0.93]), Masking (α = 0.86 [95% CI 0.85, 0.87]), and Assimilation (α = 0.88 [95% CI 0.86, 0.89]) factors.

The EGA findings in the EGA subsample aligned with the 3-factor EIFA solution found in the EIFA subsample. Three dimensions were identified in the EBICglasso network of the CAT-Q (Fig. 1A). The

Table 2
Results of the 3-factor model of the CAT-Q extracted by exploratory item factor analysis (EIFA).

Item	Factors			h^2
	F1 Compensation λ	F2 Masking λ	F3 Assimilation λ	
1. Copy body language/facial expressions	**0.55**	0.25	−0.02	0.52
4. Develop social script	**0.62**	0.20	0.07	0.64
5. Repeat phrases heard from others	**0.54**	0.27	0.05	0.59
8. Use learned behaviors from watching others	**0.57**	0.30	0.08	0.70
11. Practice natural expressions and body language	**0.74**	0.18	0.03	0.77
14. Improve understanding of social skills	**0.59**	0.17	0.17	0.62
17. Research social interaction skills	**0.86**	−0.03	−0.03	0.68
20. Learn to use bodies and face from media	**0.95**	−0.07	0.00	0.82
23. Learn skills from TV or films and use in daily life	**1.00**	−0.10	−0.01	0.87
2. Monitor face/body language to appear relaxed	0.05	**0.82**	−0.04	0.70
6. Adjust face/body language to appear interested	−0.04	**0.88**	−0.01	0.72
9. Think about impressions made	−0.03	**0.68**	0.11	0.50
15. Monitor face/body language to appear interested	0.12	**0.74**	0.15	0.78
18. Always aware of impressions made	0.22	**0.45**	−0.24	0.32
21. Adjust face/body language to appear relaxed	0.02	**0.85**	0.01	0.75
3. Rarely need to put on an act	−0.08	0.17	**0.57**	0.38
7. Feel like 'performing'	0.15	0.27	**0.61**	0.71
10. Need the support of others to socialize	0.27	0.13	**0.51**	0.53
13. Force myself to interact	0.10	0.02	**0.76**	0.65
16. Try to avoid interacting with others	0.15	−0.02	**0.72**	0.60
19. Feel free to be myself when with others	−0.20	0.04	**0.81**	0.60
22. Feel like conversations flow naturally	−0.09	−0.21	**0.87**	0.65
25. Feel like pretending to be 'normal'	0.24	0.19	**0.67**	0.80
12. Don't feel the need to make eye contact	−0.28	0.21	−0.15	0.07
24. Don't pay attention to what face/ body is doing	0.16	0.36	−0.04	0.22
Rotated SS Loadings	4.07	4.08	5.23	

Note. $N = 972$, h^2 = communality. Salient factor loadings ($\lambda \geq 0.38$) are in bold.

bootstrapped network model suggested that the 3-dimension solution replicated 61.4% of the time, and all items (except items 12 and 24) replicated in their given dimension at or beyond 80% of the time (Fig. 1C). Likewise, fast greedy community detection (Fig. 1A) corroborated the network estimation by yielding 3 communities of the CAT-Q items. A modularity score of 0.406 was calculated, indicating that around 70% of the edges between connecting nodes were within their respective communities. The item composition of the three communities overlaps identically with the three-factor EIFA solution as well as with the original 3-factor CAT-Q structure [13], aside from items 12 and 24, which were Masking items that loaded into the Assimilation community in the current network. Altogether, the dimensional structures of the CAT-Q across the EIFA, EGA, and the original CAT-Q model were nearly identical (Fig. 1B). This psychometric convergence shows that the CAT-Q performs in much the same way in the representative general population as in autism-enriched samples [13].

The EGA further provided unique fine-grained metrics on item-level importance. The expected influence centrality metric measures the sum of all incoming edge weights in a given node [70]. Using this metric, five CAT-Q items were identified as highly influential "hub" nodes with dense connections and may reflect key themes of camouflaging experiences. Items 15 (i.e., monitoring body language or facial expressions to appear interested in the interaction), 8 (i.e., using learned behaviors form watching others), and 7 (i.e., feel like "performing" rather than being myself) each captures a central aspect of the Masking, Compensation, and Assimilation communities, respectively. These items also show strong edges across communities and hence could be interpreted as inter-modular hubs that bridge different camouflaging experiences. Additionally, item 21 (i.e., adjusting body language or facial expression to appear relaxed) in the Masking community and item 25 (i.e., pretending to be "normal") in the Assimilation community were also densely connected and highly influential. These two items are more provincial, acting as intra-modular hubs within communities and hence could be interpreted as reflecting the key themes of their respective community.

A moderate to strong positive correlation ($r = 0.58$, $p < .001$) was found between CAT-Q and SPT total scores using the full sample, indicating support of convergent validity between camouflaging and self-presentation in the general population.

4. Analysis 2: What are the demographic, socio-motivational, and cognitive factors associated with CAT-Q scores in the general population?

4.1. Method: Hierarchical regression and elastic-net regression

To identify the demographic, socio-motivational, and cognitive variables associated with the CAT-Q in the general population, different regression techniques were employed. First, a two-stage hierarchical regression analysis was performed for theory-driven predictor selection. CAT-Q scores were mean-centered and all continuous predictor variables were z-score standardized prior to regression modeling. Demographic variables (i.e., gender identity, ethnicity, sexual orientation, education years, and age) were included as covariates in the nested (step-1) model. Apart from the 20 individuals who identified as gender-diverse, all other participants reported gender identities that were aligned with their sex assigned at birth (i.e., cisgender women or men). Given this high congruence, we did not include both gender and sex assigned at birth in the same regression models. Instead, we analyzed only gender as it is most interpretable given the aims of this study. Results for a sex-based analysis are provided in the Supplemental Materials. At step-2, participants' clinical diagnoses, SATQ and ASRS-A scores (i.e., autistic and ADHD traits, respectively) were added as predictors in the model. The two models were compared via a χ^2 likelihood ratio test, which assesses whether neurodivergent traits and clinical diagnoses predict camouflaging behaviors over and above demographic characteristics. Multiple comparisons were adjusted for by applying the Benjamini-Hochberg procedure at a False Discovery Rate, FDR = 0.05, to the p-values of all predictors included in the more optimal model [71] (q-values represent adjusted p-values).

Second, a regularized elastic-net regression analysis using *glmnet* [72] was fitted to identify the most important socio-motivational and cognitive predictors of CAT-Q scores. The elastic-net adds a penalty term (λ) to shrink the size of coefficients and avoid overfitting when a large pool of (and likely collinear) predictors are included in regression modeling. Neurodivergent traits (but not the other demographic variables) were included as predictors alongside the 14 socio-motivational and cognitive variables of interests. The demographic variables were not included in this analysis given the difficulty interpreting the effects of categorical variables using elastic-net regression modeling. The λ penalty parameter was optimized using a 10-fold cross-validation to

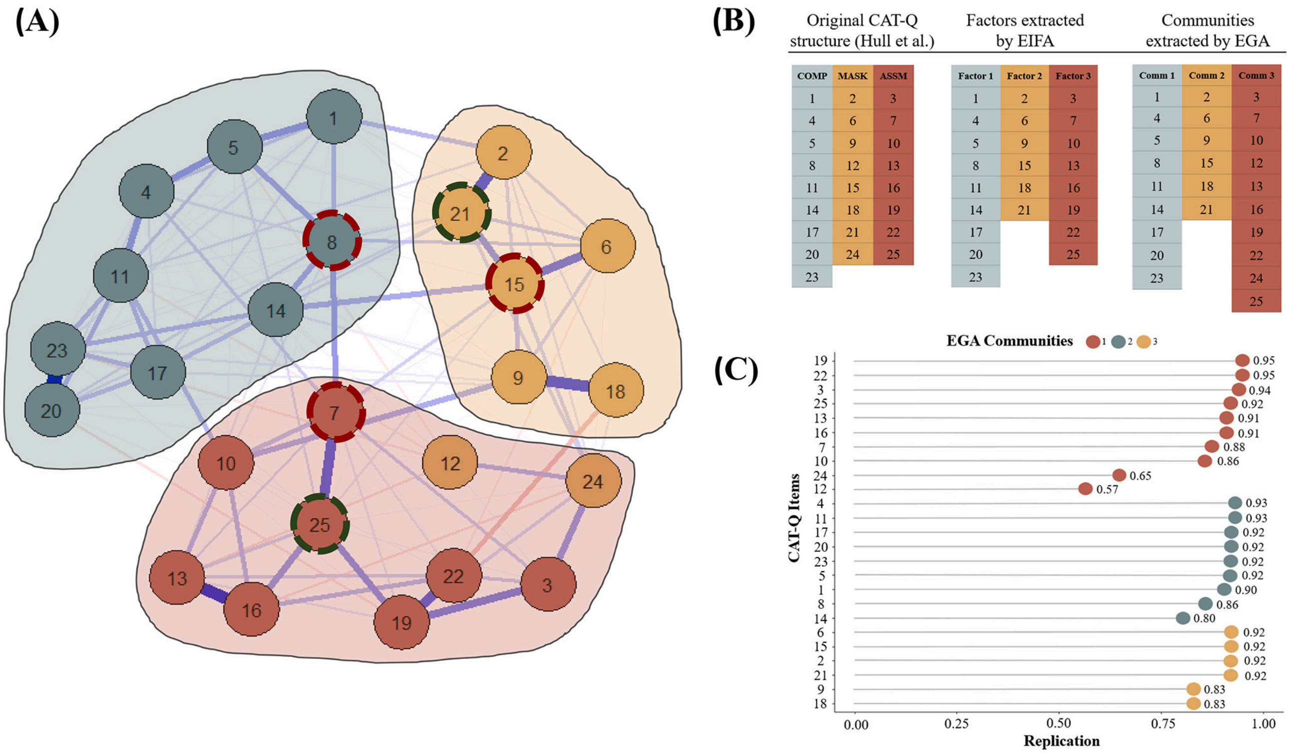

Fig. 1. (A) EGA model graphed based on estimated partial correlations with visualization of the three community structure estimated by fast greedy community detection, with the three key inter-modular hub items (7, 8, 15) highlighted with red dashed outline and the two intra-modular hub items (21, 25) highlighted with green dashed outline; (B) The factor/community/dimensional structure of the CAT-Q as estimated by the EIFA, EGA, and the originally validated model using autism-enriched samples (numbers represent item numbers); (C) Results of bootstrapped network model item replication rate within the given estimated network dimension.

produce the regularized model that is simultaneously the most parsimonious while performing within one standard error of the best model. Post-selection inference was conducted on the elastic-net via the *selectiveInference* package [73] to extract *p*-values, standard deviations, and post-selection z-scores (i.e., a proxy for effect size) of each predictor. The *p*-values of all predictors were adjusted for multiple comparisons using the Benjamini-Hochberg procedure (FDR = 0.05) [71].

4.2. Results of analysis 2

Model comparisons between the nested (step-1) and step-2 models in the hierarchical regression suggest that including the participants' clinical diagnosis information and neurodivergent traits at step-2 led to significant model improvements. The step-2 model explained an additional 14.0% of the variance in CAT-Q scores, and this change in R^2 from the nested model was significant at $F(8, 951) = 24.2$, $p < .001$. Hence, only findings from the step-2 model are reported here (βs represent standardized regression coefficients). Being a woman significantly predicted lower CAT-Q scores than being a man ($\beta = -0.16$ [95% CI -0.28, -0.05], $t(951) = -2.77$, $q = 0.030$, partial $R^2 = 0.008$). Gender-diverse individuals did not show significant differences in CAT-Q scores, although the trend indicates potentially greater camouflaging compared to either men or women. Older age predicted lower CAT-Q scores ($\beta = -0.27$ [95% CI -0.33, -0.20], $t(951) = -8.42$, $q < 0.001$, partial $R^2 = 0.069$). Higher autistic traits ($\beta = 0.21$ [95% CI 0.15, 0.27], $t(951) = 6.95$, $q < 0.001$, partial $R^2 = 0.048$) and higher ADHD traits ($\beta = 0.27$ [95% CI 0.21, 0.34], $t(951) = 8.38$, $q < 0.001$, partial $R^2 = 0.069$) each significantly predicted higher CAT-Q scores (see Supplemental Materials for full hierarchical regression results). Altogether, the step-2 model accounted for a total of 29.6% (R^2 adjusted) of the variation in CAT-Q scores, $F(20, 951) = 21.4$, $p < .001$.

Post-selection inference conducted on the elastic-net regression outputs yielded the final set of 7 statistically significant socio-motivational and cognitive predictors of increased CAT-Q scores (Table 3). These include, in order of magnitude of association: greater social comparison tendencies ($q < 0.001$, post-selection *z*-score > 37),

Table 3
Elastic-net post-selection inference metrics (beta coefficients, pre-selection *z*-scores, *p*-values, *q*-values, and post-selection *z*-scores) for each predictor of CAT-Q.

Variable	Beta coefficients	z-score	p-value	q-value (adjusted)	Post-selection z-score
Social comparison (INCOM)	6.76	9.75	< 0.001	< 0.001 ***	> 37.00
Public self-consciousness (SelfCon)	6.00	8.34	< 0.001	< 0.001 ***	> 37.00
Emotion regulation (ERQ)	3.94	6.64	< 0.001	< 0.001 ***	5.62
Autistic traits (SATQ)	4.19	5.46	< 0.001	< 0.001 ***	4.99
ADHD traits (ASRS-A)	2.38	3.39	0.001	0.002 **	3.03
Internalized stigma (ISMI-10)	2.03	3.04	0.007	0.011 *	2.43
Social anxiety (LSAS anxiety subscale)	2.62	2.35	0.018	0.023 *	2.10
Social avoidance (LSAS avoidance subscale)	2.13	1.97	0.051	0.057	1.64
Interpersonal needs (INQ)	1.83	2.56	0.080	0.080	1.41

Note. *q*-values were calculated via correcting the *p*-values extracted the elastic-net for false discovery rate using the Benjamini-Hochberg procedure; Post-selection *z*-scores were computed by converting the *p*-value from post-selection inference to provide indices of standardized effect sizes for each predictor; Significance (adjusted) codes: *** $q < 0.001$, ** $q < 0.01$, * $q < 0.05$.

greater public self-consciousness ($q < 0.001$, post-selection z-score > 37), greater emotion regulation ($q < 0.001$, post-selection z-score = 5.62), higher autistic traits ($q < 0.001$, post-selection z-score = 4.99), higher ADHD traits ($q = 0.002$, post-selection z-score = 3.03), greater internalized social stigma ($q = 0.011$, post-selection z-score = 2.43), and greater social anxiety ($q = 0.023$, post-selection z-score = 2.10). Greater social avoidance ($q = 0.057$, post-selection z-score = 1.64) and interpersonal needs ($q = 0.080$, post-selection z-score = 1.41) were not statistically significant predictors of increased CAT-Q scores but their regression coefficients survived the regularization process. The regression coefficients of all other predictors were shrunk to 0 in the elastic-net.

5. Discussion

Recent discussions underscore the need for a clearer understanding of camouflaging to substantiate the construct, its clinical significance, and relevant hypotheses [6–8]. Guided by the transactional IM framework [9], this study empirically examined the psychometric structure of the CAT-Q—the most widely used instrument to measure camouflaging—and key theoretical "drivers" of camouflaging in a large, representative U.S. general population-based sample. We found a 3-dimensional structure of the CAT-Q in the general population, with satisfactory model-fit indices and strong internal consistency. The CAT-Q also showed evident convergent validity with a measure of self-presentation, a key construct of IM. Demographically, increased age predicted lower camouflaging, and being a woman significantly predicted lower camouflaging than being a man. Increased autistic and ADHD traits both predicted greater CAT-Q scores. Significant socio-motivational predictors of camouflaging included greater social comparison, greater public self-consciousness, greater internalized social stigma and social anxiety, whereas the only significant cognitive predictor was greater emotion regulation skills.

5.1. The dimensional structure of CAT-Q in the general population

Our first aim was to triangulate the dimensional structure of the CAT-Q in the general population using two synergistic analytic approaches on split-half subsamples. The implications extend beyond scale assessment and gauges critical insights into the continuity of camouflaging experiences across diverse human groups. The methods converged to a 3-dimensional structure that can be characterized as deliberate and explicit behavioral strategies, introspective self-adjustment to conceal traits, and appraisals of camouflaging motivations during social interactions. These three themes echo the Compensation, Masking, and Assimilation subscales respectively in the original CAT-Q structure derived from autism-enriched samples [13]. Thus, our results in the general population imply that the CAT-Q measures analogous aspects of camouflaging intentions and behaviors across neurotypes, rather than specifically or only in autistic people. Further, the moderate to strong correlation between camouflaging and self-presentation provides new evidence of convergent validity, suggesting that the two jointly tap into ubiquitous IM experiences. These findings represent the first psychometric evidence in support of the transactional IM framework [9]—that camouflaging, as measured by the CAT-Q, might not exclusively measure the concealment or altering of autistic (or autistic-like) characteristics but reflect an individual's awareness of and strategic behavioral attempts to meet dominant-neurotypical social norms, mitigate stigmatization, and improve social positions more broadly—which are experiences widely reported in the general population.

Another unique contribution of the current study is the combined application of state-of-the-art psychometric analytics. By integrating multidimensional item response theory-based factor-extraction and graph theory-based community structure detection, this triangulation offers psychometric insights at different resolutions. First, the analyses corroborate the number of dimensions and item distribution of the CAT-Q. Our findings in the general population almost identically map onto the item distribution across factors in the previously found 3-factor structure in autism-enriched samples [13]. Second, at a higher resolution, EGA reveals how items relate to one another and identifies central aspects of camouflaging. Inspection of the network structure and centrality metrics unveils hub items with strong connections within and across communities. Intra-modular hubs highlight the adjustment of behavioral presentations and motivations to become "normal" as exemplar themes of Masking and Assimilation experiences respectively. Across communities, inter-modular hubs capture key links among domains of camouflaging experiences, including the performative aspect of camouflaging, the learning and generation of contextually adaptive behaviors shaped by the social environment, and the internal monitoring of body and facial presentations. This novel finding underscores critical overlaps between what has been conceptualized as camouflaging and Goffman's conceptualization of IM as a social performance with front- and back-stages [10], the employment of explicit self-presentational behavioral tactics [12,41], and the introspective elements of self-monitoring [74,75]. The bridging of these themes reiterates the conceptual overlap between camouflaging and IM across human groups. With the inclusion of corresponding measures, future research can use network-based approaches to assess unique aspects of camouflaging/IM experiences in autistic and other neurodivergent groups concerning differences in behavioral presentations, coping experiences, and well-being.

5.2. The predictors of camouflaging in the general population

Our second aim was to identify the most important theoretical "drivers" of camouflaging in the general population. Given the cross-sectional design, the findings only implicate but do not establish causal relationships. Increased autistic and ADHD traits were both associated with greater CAT-Q scores. This implicates continuity of camouflaging across neurominorities (beyond autism), individuals with sub-clinical traits, and those who are neurotypical, likely as means to modify socially undesirable behaviors and find complacency in a society geared towards different dominant social groups. However, how individuals with different neurodivergent conditions or traits approach camouflaging/IM remains elusive [21], particularly in how camouflaging/IM influences clinical presentations, the processes leading to clinical neurodevelopmental diagnoses, and psychological well-being. Whether camouflaging tendencies are predicted by other intersecting, socially discredited group identities across visible (e.g., racialized groups, physical disability) and invisible statuses (e.g., sexual orientation, mental health diagnoses) warrants further scrutiny given the limited power of the current representative sample to detect such differences related to these sociodemographic factors.

Uniquely, the observed lower camouflaging in women than men in the general population is opposite to the gender differences found in the autistic population [1]. This difference might be attributable in part to sex-based or gender-based differences in cognitive profiles that are neurotype-dependent, whereby autistic girls/women might have increased capacities for the key cognitive skills that enable enhanced camouflaging than autistic boys/men [28]. Additionally, autistic girls/women might face greater social pressure from peers or family members to blend into society due to gendered expectations of socialization [76]. Deviating from stereotyped, male-sex/gender-based autistic behavioral presentations could also thwart access to support in autistic girls/women and subsequently intensify the needs to camouflage and cope with increasingly complex social environments [77–79].

In contrast, in the general population, greater camouflaging in men compared to women aligns with longstanding IM research demonstrating that men, on average, use a wider range of impression management tactics and are more active and agentic when self-presenting than women in the organizational settings [80]. Whereas men use more self-serving forms of self-presentation to stand out and for instrumental gains, women are perceived negatively when self-presenting in assertive ways [81]. This might reflect differences in conformance to gendered social expectations and norms in how the genders are rewarded in society (e.g., in the workplace). Whereas men might tend to self-present according to masculine-typed impressions (e.g., self-promotion), women might tend to self-present in more passive, submissive, and communal manners (e.g., opinion conformity, supplication). Moreover, this finding is consistent with the transactional IM framework [9] which posits that camouflaging and IM generally function for more dominant social groups as rather voluntary, instrumental self-enhancement for achieving conventional social advantages (e.g., during job interviews), more so than a compelled survival mechanism due to societal pressures. At a trend-level, gender-diverse individuals showed greater camouflaging than both men and women in this study. Gender-diverse groups such as trans, genderfluid, or nonbinary individuals can face greater marginalization that urges camouflaging [82], but insights into this are not readily available [83]. Better powered studies that are designed to enrich the diversity of gender representation are needed to establish a more complete understanding of gender differences in camouflaging/IM in diverse populations.

The elastic-net regression analysis shows that camouflaging is most associated with interpersonal motivations. The model-selected socio-motivational predictors suggest that camouflaging needs and engagement emerge as one evaluates their match with the interpersonal-social context and the social anxiety that arises from perceived misalignment (e.g., being subject to social evaluation) and stigmatization. Thus, camouflaging requires an extent of social awareness (i.e., being aware of how oneself appears publicly and compares to others socially) for one to be motivated to enhance social impressions during interactions. The general population-based findings here align with reports from autistic individuals on the contexts and reasons for camouflaging [5,26,27] and are consistent with the motivations of IM that pervade different social groups [20,84]. Therefore, camouflaging and IM are likely fundamentally driven by comparable social needs and pressures across human groups, although these pressures might be exacerbated for marginalized groups, including autistic people. Future work should disambiguate nuanced differences in motivations to merely enhance social connections or to avoid social exclusion, mitigate negative perceptions, and prevent harm and threats to well-being.

Meanwhile, the only significant cognitive predictor of camouflaging in the general population is emotion regulation. This finding is in line with the prediction that "emotion labor" in successful IM also critically supports camouflaging [9,33]. Unlike what we hypothesized, executive function and perspective taking did not significantly predict camouflaging. These cognitive capacities have been speculated to work in concert in supporting autistic camouflaging [28] and empirically shown to support IM in the general population [31,32,35]. It is therefore important to reflect on potential reasons for the lack of significant relationships among these variables. It might be that interpersonal motivations are more greatly associated with camouflaging than are cognitive skills, but we are cautious in this interpretation. One key limitation of our study is that only self-report measures were included. Cognitive characteristics described via subjective self-report do not always equate cognitive capacities measured through task-based performances [85]. Also, the use of short self-report measures might not be reflective of everyday executive functioning and perspective taking abilities, particularly in complex social situations. These cognitive skills might instead be better assessed with performance-based tasks or unified measures on everyday executive functioning such as the Behavior Rating Inventory of Executive Function for Adults (BRIEF-A) [86], or the combination of both.

Equally, the CAT-Q only measures the intentions and use of camouflaging behaviors through self-reflection, but does not measure how effective camouflaging is in real-life settings [87]. Executive function and perspective taking might predict successful or more sophisticated camouflaging in actual behavioral presentations or social coping performance, whereas socio-motivational measures predict self-perceived camouflaging needs and engagement. In addition, it has been hypothesized that differing cognitive capacities can determine "shallow" (e.g., engaging in mimicry) versus "deep" (e.g., dynamically tailoring behaviors to contextual social inferences) forms of camouflaging [30,88].

5.3. *Limitations and future directions*

Several limitations need to be considered. First, all measures were from self-report. This measurement constraint might have limited insights into the cognitive predictors and effectiveness of camouflaging during social situations. In future work, performance-based measures of cognitive skills and camouflaging [8,29] should be incorporated alongside self-report measurements. Several other operationalizations of camouflaging exist [8]. Future research should consider also employing measures that quantify the effectiveness or capacity for camouflaging, such as the self-monitoring scale [74], the discrepancy operationalizations of camouflaging [29,30], or other potential ways that tap into the construct's automatic or unintentional aspects. These alternative measurements can yield additional insights on aspects of camouflaging/IM that the current study is unable to illuminate. Future research can also consider employing self-report scales with items that measure the success or effectiveness of camouflaging/IM (e.g., the self-monitoring scale) [75]. Further, the study is cross-sectional and can only probe but not establish causal links between camouflaging/IM and its cognitive and socio-motivational correlates. Longitudinal and experimental studies are warranted to validate these predictive relationships. Lastly, although a representative general population sample enables greater generalizability overall, nuances of camouflaging in smaller sociodemographic groups, such as gender minorities, and their intersections, might have been missed.

Nonetheless, the findings signpost pivotal future research directions. It is important to delineate the circumstances in which camouflaging/IM succeeds or falls short, and to unpack the complex individual and gender differences in degrees of camouflaging/IM awareness, motivation, success, and effort. In addition, the downstream mental health (e.g., depression, anxiety, inauthenticity) and social outcomes of camouflaging/IM should be evaluated in conjuncture with recent autism studies and past IM research. Camouflaging/IM links social psychology and psychopathology research, hence understanding it paves way for a clearer outlook on how socializing and stigma-management strategies manifest across different social-identity and clinical groups [26], as well as the mental health consequences that arise.

Although the current findings suggest that camouflaging falls within the conceptual umbrella and continuity of IM, we emphasize the need for future research to gauge how camouflaging, as a form of IM, also manifests in unique ways in autistic and other neurodivergent individuals [9]. For example, distinct challenges in the efficiency, effort, and time taken to decode social scenes in a pervasively neurotypical world during camouflaging/IM can impose greater tolls on autistic than neurotypical people. Therefore, camouflaging/IM needs to be studied as a context-dependent endeavor between the individual and the social environment. Clinically, it is critical to re-evaluate prevailing social skills intervention programs for neurodivergent people [89] by analyzing and evaluating the motivational, behavioral, cognitive, and mental health links to camouflaging/IM. Researchers and clinicians can also leverage insights from the broader IM phenomena to develop more optimal strategies and environmental adjustments in improving the quality of life for autistic and other neurodivergent people, in ways that go beyond the conventional individual-focused social skills-building efforts.

6. Conclusion

This study advances our understanding of camouflaging across the general population and maps further development directions. The construct of camouflaging, as a kind of IM, appears to overlap psychometrically and socio-motivationally between the general population and autism-enriched samples. Camouflaging converges with self-presentation in the general population and associates with comparable socio-motivational factors identified in prior IM research. These lines of evidence provide support for the idea that IM is conceptually inclusive of camouflaging. By reframing camouflaging within IM, future work can clarify the clinical relevance and nuances of camouflaging across human populations.

CRediT authorship contribution statement

Wei Ai: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Project administration, Software, Validation, Visualization, Writing - original draft, Writing - review & editing. **William A. Cunningham:** Conceptualization, Methodology, Formal analysis, Investigation, Supervision, Writing - review & editing. **Meng-Chuan Lai:** Conceptualization, Methodology, Formal analysis, Investigation, Funding acquisition, Data curation, Project administration, Resources, Supervision, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

W. Ai: No conflicts of interest directly related to this work.

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M.-C. Lai: No conflicts of interest directly related to this work. M.-C. Lai has received editorial honorarium from SAGE Publications.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.comppsych.2023.152434.

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