Framing mental health questions using context better predicts disability than does frequency

Authors: Anirudh Krishnakumar* [1,2, 3], Mauricio Scopel Hoffmann* [4, 5, 6], Felix Schoeller [1], Jon Clucas [3], Jake Son [3], Lena Müller-Naendrup [1], Giovanni A. Salum [6], Michael P. Milham [3], Ariel B. Lindner [1,2], Arno Klein* [3]

[1] Centre for Research and Interdisciplinarity, University of Paris, France

[2] U1284 INSERM, Paris France

[3] Child Mind Institute, New York, USA

[4] Care Policy and Evaluation Centre at London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, UK

[5] Universidade Federal de Santa Maria, Departamento de Neuropsiquiatria, Avenida Roraima 1000, Santa Maria, 97105-900, Brazil (UFSM)

[6] Universidade Federal do Rio Grande do Sul, Department of Psychiatry, Rua Ramiro Barcelos 2350, Porto Alegre,

90035-003, Brazil (UFRGS)

* correspondence: anirudh.krishnakumar@cri-paris.org, mauricio.hoffmann@ufsm.br, arno@childmind.org

Abstract

Most mental health questionnaires only probe behavior and emotion over one domain (e.g., frequency) by using an adverbial phrase such as 'How often...?'. This single-domain approach to behavior sampling may limit the scope of psychiatric evidence that these instruments can capture. We investigated whether adding domains such as intensity, duration, ability and context to mental health survey instruments garner responses that better characterize or measure relevant symptoms or behaviors, testing its association with relevant outcomes. We tested whether our multidomain instrument could be associated with hospitalization, self-harm, education, and disability. 1,504 participants took an augmented version of the SWAN questionnaire ('SWAN+'), where 4 domains were added to the ability domain already present (frequency, duration, intensity, and context). First, we used structural equation models and the tri-factor modelling to analyze if the latent construct of domains was independently associated with the outcomes. Our results suggest that adding domains such as frequency and context could help characterize disability beyond the domain originally probed by the SWAN questionnaire. Different domains had different predictive effects across outcomes measured in the study. We also complemented results from the tri-factor modelling with a more classical approach, by performing regressions on the summed scores on each domain and the entire scale, adjusted by age and gender. Second, analyses were performed to identify the best predictor domain within each question to predict disability. Significant results were found for the ability and context domains on practically all questions ($p < 0.001$), revealing that they are important for almost all questions, whereas frequency is predictive for only a subset of them. This confirmed the results of the tri-factor analysis demonstrating the clinical utility of our findings. It also indicated that context is more predictive than frequency, that ability and context should be uniformly applied, and that the ubiquitous frequency phrasing is not uniformly as informative in our study. Overall, our results suggest that the 'multidomain' approach to questionnaires may improve inferences about mental health and predictions of functional outcomes. Framing questions using appropriate and relevant domains seems critical to measure psychopathology adequately, as opposed to asking solely about the frequency or recurrence of any given symptom.

Keywords: behavior sampling, questionnaire design, domains - frequency, intensity, ability, context, duration, symptoms, attention deficit and hyperactivity disorder, SWAN, WHODAS, functional outcome, hospitalization, self-harm, education, disability, tri-factor modelling, DSM, framing effect.

1. Introduction

To characterize the behavior and condition of patients/people, mental health questionnaires frame questions representing domains such as frequency, place and time (i.e., context), duration, and intensity. However, the majority of questionnaires measure behaviors and illnesses along a single domain such as frequency or the recurrence of the behavior or illness, with domains such as duration and context less commonly measured across different disorders.¹ Previous studies have formulated questionnaires to assess mental health problems by exploring domains simultaneously, such as frequency, duration and intensity, but indicate difficulties in reliably assessing the intensity domain.² Moreover, evidence from cognitive bias literature exploring the ‘framing effect’ suggests that it is possible to create incentives to obtain different information from subjects depending on how we ask the question.^{3,4,5} Hence, it is possible that different phrasing on questions about mental health can be advantageous to obtain clinical information.

The single-domain approach that dominates mental health questionnaires might limit the inferences one can draw based on the participant’s/patient’s responses and the amount or type of information that can be derived from the instrument. For example, the question “How often do you get nervous?” probes the frequency of being nervous, but not the intensity of being nervous. This may fail to capture some information that could be critical to distinguish unhealthy and healthy stressors, such as for example the distinction between spontaneous bouts of anxiety and the fear of public speaking. To the best of our knowledge, no study has yet examined the predictive effect of applying different domains (e.g., frequency, duration, intensity, ability and context) to the same core questions.

In this study, we investigated whether adding multiple domains to mental health questionnaires could help better characterize symptoms/behaviors of both positive and negative outcomes. Specifically, we studied how framing psychiatric questions over multiple domains could improve statistical inferences, and thus allow for more accurate predictions of functional/behavioral outcomes. To do this, we set out to answer two key research questions. First, does the addition of new domains better predict functional and behavioral outcomes than single domain approaches? Second, which domain (among frequency, intensity, duration, context and ability) within each question best characterizes outcomes such as disability?.

We operated on the “Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale (SWAN)” questionnaire,⁶ a questionnaire used in the assessment of Attention-Deficit/Hyperactivity Disorder (ADHD) that probes relative strength of abilities rather than weaknesses (presence or absence of ADHD symptoms), as seen in most counterparts. As part of a research study on the design of mental health questionnaires (see Figure 1), we assessed whether augmenting SWAN by adding domains (SWAN+) could better measure functional outcomes.

Figure 1. From SNAP to SWAN+. Our study is part of a larger study of mental health questionnaires. The SWAN is now widely used, and its validity established and on-par with traditional counterparts for measuring ADHD-related behavior.⁶⁻⁸ It has a 7-point response scale ranging from good to bad, inclusive of both less symptomatic or non-affected populations. Factor analysis and summary statistics (mean, skewness, SD) were used to compare and validate SWAN with its source, SNAP. The team that created the SWAN also argued for the advantage of its approach by pointing out that other questionnaires need complicated statistical analyses (e.g., assigning T and Z scores) due to limitations caused by their questionnaire designs.⁶⁻⁸ The E-SWAN aimed to extend and test SWAN’s approach beyond ADHD; questions were modified and re-worded from DSM symptoms into behaviors to reflect strengths and weaknesses in major depressive, panic, social anxiety and disruptive mood dysregulation disorders.⁹ The original SWAN questions probe the domain of ability. We augmented SWAN to create “SWAN+” by generating additional questions probing new domains such as frequency, duration, intensity and context.

We hypothesized that adding multiple domains to questions in psychiatric assessments of symptoms and behaviors will help better predict disability variance (i.e., 'Getting along with people' and 'Life activities' sections of the World Health Organization Disability Assessment Schedule (WHODAS))¹⁰ in our study, above and beyond the general latent factor or specific item/question factor. In the specific context of SWAN, we tested the null hypothesis that the predictive value of assessments with added domains would be equivalent to assessments with fewer existing domains, in terms of explaining the disability variance. In order to assess whether specific domains or the additive effect of domains in a questionnaire could better predict functional outcomes, we tested how well the domains predict functional outcomes (such as hospitalization, level of education or self-harm). We tested the null hypothesis that different domains are equally good at characterizing symptoms and behaviors. The rationale here is that since existing questionnaires lack multiple domains, they may be missing domains that could be better predictors. Answering these questions can lead to smarter questionnaire design, may improve statistical inferences, and allow for more accurate predictions in mental health.

2. Methods

2.1. Methodological context

2.2. Participants

We recruited participants using Prolific Academic (<https://prolific.ac/>), an online crowdsourcing platform used for data collection.^{11,12} Parents (N=1,504) with young children (ages 6-17, 730 females) completed surveys and were provided with a small monetary compensation (see Table 1). Sample sizes per age group were for ages 6 to 8 (n=312); 9 and 10 (n=255); 11 and 12 (n=293); 13 and 14 (n=272) and 15 to 17 years old (n=372). No siblings were included in the final sample. All participants whose responses were recorded signed consent forms. No data containing personal health information or personally identifiable information were collected.

2.3. Procedure

Participants were invited to take part in an online study on the platform. First, participants who fit the inclusion criteria (parents with children of ages 6-17) could access the study and its description. Second,

those interested to participate signed a consent form and were informed about their rights. Third, they answered our questionnaire (with questions from the original SWAN questionnaire⁶ and from the SWAN+, an extended version of the SWAN that probes additional domains for comparison). Participants also answered questions related to demographics, educational attainment, hospitalization, self-harm and the D4 (Getting along with people) and D5 (Life activities) sections of the WHODAS).⁹ The entire questionnaire is available in supplementary table 1. The questionnaire was automatically closed once the desired number of participants was reached.

2.4. Materials

2.4.2. Questionnaire construction process (SWAN+)

Construction and Standardization

We constructed the augmented SWAN (SWAN+) questions from the 18 SWAN items,⁶ and their corresponding behaviors. Each question in the SWAN has a prompt (‘How does your child do the following behavior compared to other children’) to probe for ability, with each of the 18 questions corresponding to a particular ADHD behavior. Our first step was to remove this prompt and derive the 18 underlying behaviors. As an illustrative example, from ‘How does your child give close attention to detail and avoid careless mistakes?’, we derived the underlying behavior ‘Give close attention to detail and avoid careless mistakes’. Inspired by the SWAN,² and E-SWAN,⁵ questionnaire design, we used a standardized process for questions to have consistent language and formatting throughout. We applied domains (frequency, duration, intensity and context) to the underlying behaviors to generate questions for multiple domains.

Prompt construction

We constructed prompts for the frequency (‘How often does your child’), duration (‘How long does your child’), intensity (‘How intensely does your child’) and context (‘When does your child’) domains we wanted to probe. For clarity, the overall question instruction (‘Compared to other children, how well does your child do the following’) in the SWAN⁶ was added as a post-prompt (‘compared to other children’) at the end of each question rather than just once at the beginning of the questionnaire.

Question construction

We applied domain-specific prompts to each of the 18 underlying behaviors to generate new questions (pre-prompt + behavior + post-prompt). We also retained the original SWAN⁶ questions reflecting the ‘ability’ domain through the ‘How does your child’ prompt. Thus, each behavior was represented by a total of 5 domains: frequency, duration, intensity, context, and (the existing original domain of) ability. The aggregate of these five domains constitute an item. The SWAN+ questionnaire contains 18 items over 5 domains for a total of 90 questions.

Response format

We maintained a uniform 5-point Likert response scale across all domains. This was also realized for the ability domain (which was probed in the original SWAN questionnaire)² by removing the ‘Below average’ and ‘Above average’ options to bring the 7-point Likert scale in the original SWAN to a 5-point Likert scale (‘Far below average’, ‘Slightly below average’, ‘Average’, ‘Slightly above average’, ‘Far above average’) in SWAN+. The response options associated with each domain is listed below in Fig.2

Disabilities/Difficulties in performing life activities

To assess disabilities or difficulties faced in social, household and life activities, we used the World Health Organization Disability Assessment Schedule 2.0 (WHODAS) questionnaire.¹⁰ We included the D4 (Getting along with people) and D5 (Life activities) sections of WHODAS. We also included questions probing for self-harm, hospitalization, and education (number of years studied in school and number of years (grades) repeated in school). We didn’t ask any questions about personal health or identifiable information.

Figure 2. Augmented SWAN (SWAN+) Questionnaire development. Inspired by the E-SWAN questionnaire design process,⁹ we constructed questions with multiple (frequency, duration, intensity and context) domains having consistent language and formatting. This schema details the questionnaire construction process for our SWAN+ questionnaire. The complete questionnaire can be found in Table 1 of the supplementary information.

2.5. Ethics

The experiment is in compliance with the Helsinki Declaration. As this was an online study, all recruitment and contact with participants were made through the Prolific Academic Platform and the study coordinators were blind to the participants or their personally identifiable information. Participants registered to the platform already signed ethics/consent forms with regard to their data being collected by the platform. All participants who took part in the study gave their voluntary informed consent and we

followed the Ethics Code of the American Psychological Association. All participants were informed about the purpose of the research, about their right to decline to participate and to withdraw from the experiment and about the limits of confidentiality. We also provided them with a contact for any questions concerning the research and with the opportunity to ask any questions regarding the phenomenon under study and to receive appropriate answers.

2.6 Statistical analysis

A classical test using sum scores on the prediction of the outcomes

Classic regression models using sum scores

We first performed regressions to explore how much of the outcomes would be predicted by the summed scores of the entire scale, the ‘attention factor’, the ‘activity factor’, domains and questions, adjusted by age and gender. The purpose of this analysis was to delineate the associations of domains and reveal the predictions of the scale if scores were summed and considered separately (model 1) or simultaneously in a multiple regression model (model 2), to complement the tri-factor analysis method where all latent factors were included as predictors (model 3, described below). For models 1 and 2, we summed all 90 questions (18 questions * 5 domains each) for the total score, the first 45 questions for the ‘attention factor’, the last 45 questions for the ‘activity factor’, 18 questions for each domain (e.g., all questions with the frequency domain) and 5 for each question (i.e., a question represented by each of the domains).

Questionnaire modeling with the tri-factor analysis

The primary analysis method used was the tri-factor model analysis, a type of Confirmatory Factor Analysis. The advantages of using tri-factor measurement models against traditional counterparts for modeling multi-informant data have been recently highlighted.^{13,14} As elucidated by Bauer et al, 2013,¹³ the model is an extension of the bifactor model (Holzinger and Swineford, 1937),¹⁵ which separates general factors from specific factors (in the present case, attention and activity) in a given questionnaire (or instrument). The key feature is that tri-factor modeling separates what it stipulates to be three separate sources of variability, namely the common (i.e., consensus) view of the target, the unique (i.e., independent) perspectives of each informant, and specific variance associated with each item of the questionnaire (question). The purpose is to evaluate item quality in questionnaires, test sources of variability (e.g., from the trait itself, question framing or items), and provide scores related to each source variability to test its predictive validity. The model, by virtue of its identification of items with respect to

both shared and unique perspectives of the informants, improves the characterization of informant convergence and discrepancy.¹⁴

We applied the tri-factor model to analyze our data, with a slight modification of source variability modeling. Instead of measuring the informant perspective, we modeled the domains, together with the general and specific attentional and activity factors of the questionnaire (construct itself) and the item (question) factor, as depicted in Figure 3.

Through the analysis of domains and the individual items, we summed up information from each domain. These models will help disentangle item (question) effect, separating effects of domains from behaviors themselves (disentangle frequency, context, intensity and duration aspects of a given behavior, from, for example, the attentional trait that these domains are built in). Such a model provided the predictive validity of each domain, separating it from the predictive validity of the item of interest and also from the overall effect of the measured construct, independently from domains. If the specific domain factor proves reliable and predictive, framing questions into domains might be useful for measuring psychopathology, instead of questioning only how much of the symptom a given subject has.

Figure 3. Tri-factor model example for the present study

The tri-factor model was tested using confirmatory factor analysis (CFA). CFA was performed in R using the *lavaan* package (Rosseel et al., 2018),¹⁶ applying delta parameterization and weighted least square with diagonal weight matrix with standard errors and mean- and variance-adjusted chi-square test statistics (WLSMV) estimators. Model fit parameters were Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI) and Tucker Lewis Index (TLI). Values of RMSEA near or below 0.080 represent acceptable model fit, and values lower than 0.060 represent good-to-excellent model fit (Hu and Bentler, 1999).¹⁷ CFI and TLI values near or above 0.900 represent acceptable model fit, while values higher than 0.950 represent a good-to-excellent model fit. After running the tri-factor model, we extracted the factor scores for each individual in order to use as predictors or the described outcomes

To assess the reliability of the tri-factor model, we used omega (Raykov, 2001)¹⁸ (ω , a model-based reliability estimate, appropriate for models which have varying factor loadings) and the hierarchical omega coefficient (Rodriguez et al., 2016)¹⁹ (ω_H , which judges the degree to which

composite scale scores are interpretable as a measure of a single common factor and is more conservative than the ω coefficient). The omega estimate is suitable for congeneric tests where entities belong to the same measure but with different weightage, in contrast to the alpha coefficient which is used when all items/questions belong to the same measurement by the same amount.

Values of ω and ω_H coefficients vary between 0 and 1, where higher scores indicate greater reliability.

Outcomes of modeling

WHODAS was modeled using a second-order model adapted for the three first-order factors ('Getting along with people', 'Household activities' and 'Life activities') that were used in the study, since the first and third factors did not converge in the factor analysis. This is based on previous literature where factor analysis of the WHODAS revealed a two level hierarchy with one general disability factor feeding into the six subfactors.²⁰ In other words, WHODAS was modeled using an over-arching disability factor (second-order factor), which loaded into two first order factors. These first-order factors then loaded into their items. All first-order factors were correlated only via the second-order factor. We also ran an additional structure whereas 'life activities' items loaded in the same first order. However, this last model did not converge.

Other outcomes were years of schooling ("How many years of schooling has your child completed?"), school retention ("How many grades (years in school) has your child repeated?", binarized as yes/no), hospitalization ("Has your child been hospitalized in his/her lifetime?": yes/no) and self-harm ("Has your child engaged in self-harm in his/her lifetime?": yes/no). Age and gender were used for adjusted regression models.

Regression models

A multiple regression model (model 3) was estimated after all factor scores from latent models were extracted. This model included all tri-factor latent factors as predictors, alongside age and gender. In these models, the additive main effect of domains and questions to the general factor could be observed. Logistic regression models were used for binary outcomes (school retention, hospitalization and self-harm). Linear models were used for years of schooling and WHODAS general disability/impairment factor. All analyses were performed in R, using the *finalfit* package by Harrison, Drake and Ots.²¹ All

regression models were adjusted to the False Discovery Rate (FDR) method, proposed by Benjamini and Hochberg.²²

From the total sample (N=1,515), 1,504 subjects fell within the age range (children of ages 6-17, 730 females) used in the study. No siblings were included in the final sample. The final sample description can be found in Table 1.

Table 1 - Description of sample variables

	All (N=1504)	Female n=730	Male n=774	Gender differences (p-value)
Age (years)	11.7 (3.17)	11.7 (3.17)	11.7 (3.17)	0.882
Schooling (years)	7.05 (3.16)	7.15 (3.17)	6.96 (3.16)	0.264
Hospitalization (lifetime)	676	309 (42.3%)	367 (47.4%)	0.054
Self-harm (lifetime)	148	84 (11.5%)	64 (8.27%)	0.043
School Fail	55	22 (3.01%)	33 (4.26%)	0.249
Disability (WHODAS factor score)	0.05 (0.85)	0.00 (0.84)	0.11 (0.85)	0.009
Instrument factor scores				
General factor	0.00 (0.94)	0.17 (0.91)	-0.16 (0.94)	<0.001
Attention	0.00 (0.84)	0.07 (0.84)	-0.06 (0.83)	0.002
Activity	0.00 (0.76)	0.05 (0.76)	-0.05 (0.75)	0.008
Ability	-0.01 (0.81)	0.05 (0.82)	-0.06 (0.80)	0.010
Frequency	0.00 (0.73)	-0.01 (0.72)	0.00 (0.74)	0.730
Duration	0.00 (0.63)	0.00 (0.62)	0.00 (0.64)	0.934
Intensity	0.00 (0.75)	0.01 (0.74)	-0.01 (0.77)	0.633
Context	-0.01 (0.87)	0.00 (0.82)	-0.01 (0.91)	0.818

Note: Gender differences in binary variables were tested with a χ^2 test. Gender differences in continuous variables were tested with a t-test.

Towards identifying the best domain within a question to measure outcomes

Additionally, for each question, we examined what would be the best domain to capture functional assessment, in the hope of providing clinically useful recommendations. With regard to the 18 ADHD-related questions in SWAN,⁶ other response domains could be better suited with, for example, frequency for question 1, intensity for question 2, and so forth). For this ‘domain within a question analysis’ to identify which domain (within a question) captures most variance, we ran multiple regression models using the five domains of each question to predict the disability outcome from the WHODAS. Running multiple regression models with all 5 domains at once could help identify the best composite domain out of the 18 items (i.e, 18*5 questions with each question representing a domain in the item). Hence, we used WHODAS as the outcome while performing multiple regression using all domains of each question (18 regressions and 5 predictors), since the strongest association we found in the tri-factor analysis was with WHODAS.

3.Results

A classical test using sum scores on the prediction of the outcomes.

Regression models using sum scores

The results of the regression analysis with the predictions of the composite summed scores for each domain adjusted by age and gender (regression with scores summed and estimated separately, with each predictor at a time (model 1) and regression scores summed and considered simultaneously (model 2) can be found in Table 2, with complete data for models 1 and 2 found in supplementary tables 2 and 3 respectively. Model 2 shows predictions of multiple models, in which all sum scores were included in the models alongside age and gender. Results from this analysis revealed that some domains were associated with disability (WHODAS factor scores) independently from other predictors derived from the scale. Nonetheless, given that the analysis used sum scores from the same items, not all domains and questions were associated with disability due to singularities with other predictors, and for example, it was not possible to access the context domain with the multiple regression analysis. Factor models improve this, since they can be modelled orthogonally (using factor scores compared to sum scores) enabling all predictors to run in the regressions. Results from the tri-factor model (model 3) are presented below.

Tri-factor model results

The tri-factor model showed excellent fit indices (RMSEA = 0.034; 90%CI = 0.034 – 0.035; CFI = 0.998; TLI = 0.998). Two items have been removed due to residual negative variance (questions about frequency and duration of playing quietly). Despite the fit, it is important to keep in mind the moderate reliability of using subscales when interpreting latent information provided by the present instrument, given the low to moderate ω and ω_H reliability indices (Supplementary Table 4). Factor loadings of the tri-factor model are presented in the factor loading Supplementary Table 5. Factor loadings are the square root of a given item's percentage of variance explained by the latent factor. After running the tri-factor model, we extracted the factor scores for each individual in order to use them as predictors of the described outcomes. This score indicates the subject's position on the latent trait, expressed as standardized units, with a mean of zero.

WHODAS latent model

The WHODAS second-order model resulted in a good fit for the data (RMSEA = 0.072; 90%CI = 0.066 – 0.078; CFI = 0.999; TLI = 0.999). The WHODAS general disability/impairment factor was extracted for each individual and used as the WHODAS outcome variable.

Regression models

Table 2 - Regression results from the classical measurement theory approach using sum scores (model 1 using only one domain sum score at a time and model 2 using all domain sum scores simultaneously), and the more modern tri-factor analysis method using latent factor scores (model 3), shown together

Predictors	Hospitalization		Self-harm		Years of schooling		School Fail		Disability (WHODAS factor score)	
	Odds Ratios	95% CI	Odds Ratios	95% CI	Incidence		Odds Ratios	95% CI	β	95% CI
					Rate Ratio	95% CI				
Associations of domain sum scores regressed each at a time on each outcome, adjusted by age and gender										
Ability	1.00	0.85 – 1.17	0.38**	0.30 – 0.50	1.01	0.98 – 1.04	0.55**	0.38 – 0.81	-0.78*	-0.83 – -0.72
Frequency	0.96	0.79 –	0.29**	0.21 –	1.02	0.98 –	0.53*	0.33 –	-1.00*	-1.06 –

		1.17	*	0.40		1.06		0.85	**	-0.93
		0.88 –	0.38**	0.28 –		0.98 –		0.40 –	-0.84*	-0.91 –
Duration	1.05	1.26	*	0.51	1.02	1.05	0.63*	0.99	**	-0.78
		0.86 –	0.38**	0.28 –		0.98 –		0.38 –	-0.87*	-0.94 –
Intensity	1.05	1.27	*	0.52	1.01	1.05	0.61*	0.99	**	-0.80
		0.78 –	0.33**	0.25 –		0.98 –		0.33 –	-0.87*	-0.93 –
Context	0.93	1.11	*	0.44	1.01	1.05	0.49**	0.74	**	-0.81
Associations of domains sum scores regressed simultaneously on each outcome, adjusted by age and gender										
		0.64 –		0.23 –		0.94 –		0.12 –	-0.41*	-0.53 –
Ability	0.95	1.40	0.45	0.88	1.01	1.08	0.34	0.92	**	-0.28
		0.45 –		0.14 –		0.91 –		0.26 –	-0.36*	-0.54 –
Frequency	0.78	1.36	0.36	0.90	1.01	1.12	1.07	4.40	**	-0.18
		0.85 –		0.74 –		0.92 –		0.59 –		-0.04 –
Duration	1.52	2.72	2.07	5.85	1.03	1.14	2.87	13.86	0.15	0.34
		0.65 –		0.78 –		0.88 –		0.37 –		-0.10 –
Intensity	1.11	1.89	2.10	5.66	0.97	1.07	1.66	7.50	0.07	0.24
		0.55 –		0.27 –		0.93 –		0.16 –	-0.40*	-0.52 –
Context	0.79	1.12	0.47	0.83	1.00	1.06	0.37	0.86	**	-0.29
Associations of domains factors derived from the tri-factor model, adjusted by age and gender										
		0.82 –		0.63 –		0.98 –		0.46 –	-0.09*	-0.14 –
Ability	0.95	1.08	0.80	1.03	1.01	1.03	0.67	0.97	**	-0.05
		0.77 –		0.66 –		0.98 –		0.62 –	-0.10*	-0.15 –
Frequency	0.91	1.07	0.89	1.19	1.01	1.04	0.94	1.43	**	-0.04
		0.82 –		0.96 –		0.97 –		0.57 –		-0.11 –
Duration	0.98	1.18	1.30	1.76	1.01	1.04	0.89	1.38	-0.05	0.00
		0.85 –		0.93 –		0.97 –		0.60 –		-0.00 –
Intensity	0.99	1.14	1.23	1.63	1.00	1.03	0.92	1.41	0.04	0.09
		0.80 –		0.63 –		0.97 –		0.49 –	-0.11*	-0.15 –
Context	0.91	1.04	0.79	0.99	1.00	1.02	0.68	0.94	**	-0.07

Note: For the regressions using sum scores (complete data in supplementary tables 2 and 3 respectively), predictor scores are from 1 to 5. Sum scores are the sum of all items that composes the domain divided by the number of items. Each predictor row represents a predictor in the regression model, adjusted by age and gender. The complete results of the multivariate regression associations of factors derived from the tri-factor model can be found in supplementary table 6. For all, p-values are adjusted for false-discovery rate. * p<0.05 ** p<0.01 *** p<0.001

The complete results of the multivariate regression associations of factors derived from the tri-factor model, adjusted by age and gender, on the study outcomes can be found in Supplementary Table 6

After FDR correction, associations remained between the instrument's factor scores (general, domains and questions) with disability (WHODAS factor score) and self-harm. Regarding the whole sample, disability was negatively associated with the domains ability ($\beta = -0.10$, 95% CI= -0.14 to -0.06, $p < 0.001$), frequency ($\beta = -0.10$, 95% CI= -0.15 to -0.05, $p < 0.001$) and context ($\beta = -0.12$, 95% CI= -0.16 to -0.08,

$p < 0.001$), as well as question 4 ('follows through on instructions') ($\beta = -0.18$, 95% CI= -0.24 to -0.11, $p < 0.001$). Questions 13 ('play quietly (keep noise level reasonable)') ($\beta = 0.09$, 95% CI= 0.04 to 0.15, $p < 0.001$) and 15 ('modulate verbal activity (control excessive talking)') ($\beta = 0.06$, 95% CI= 0.01 to 0.11, $p = 0.034$) are associated with higher levels of disability in the whole sample. Aside from these, the instrument's general factor and attention factor are associated with lower levels of disability (supplementary table 6).

Question 4 (Odds Ratio = 0.55, 95% CI= 0.37 to 0.80, $p = 0.011$) and question 7 ('keep track of things') (Odds Ratio = 0.64, 95% CI= 0.48 to 0.85, $p = 0.011$) are also associated with a lower OR for self-harm in the whole sample i.e., a child who keeps track of things or follows through on instructions is less inclined or likely to engage in self-harm. These results suggest that adding domains such as frequency and context could help characterize disability besides domains originally probed by the SWAN questionnaire (i.e., ability). However, the same relationship was not observed consistently (e.g., between these domains and self-harm). Hence, the addition of domains to SWAN+ questions may predict disability, but not educational levels or hospitalization. However, concerning educational levels, no factors from the present SWAN+ (no domains, general or specific factor and questions) predict the 'years of schooling' or 'school fail' outcomes. From an analytical perspective, both classical and modern measurement theory analyses showed some consistency with the ability and context domains predicting disability in both sum score regressions and tri-factor model analyses respectively

Best-domain within a question analysis results

Concerning the best domain within each question to measure outcomes, we listed in Table 3 the results from the multiple regressions using all domains of each question (18 regressions, 5 predictors plus age and gender) to predict disability using WHODAS as the outcome (the strongest association found in the tri-factor analysis). Significant results were found for the ability and context domains on practically all questions ($p < 0.001$), revealing that ability and context are important for almost all questions, whereas frequency is predictive for only a subset of them, i.e. the ability to regulate attention/activity as well as context in which a child expresses these traits are important in almost all questions to predict disability. Thus, it indicates that context is more predictive than frequency, that ability and context should be uniformly applied, and that the ubiquitous frequency phrasing is not uniformly as informative with respect to the questions and outcomes measured in our study.

Table 3 - Results from the ‘best domain within a question’ analysis using all domains of each question (18 regressions, 5 predictors plus age and gender), using WHODAS (standardized factor scores) as outcome.

	Frequency	Ability	Duration	Intensity	Context	Nagelkerke's R2
Question 1	-0.15 ***	-0.19 ***	-0.14 ***	0.05	-0.15 ***	0.313
Question 2	-0.12 **	-0.25 ***	-0.04	-0.03	-0.20 ***	0.337
Question 3	-0.11 **	-0.13 ***	-0.10 **	-0.08 *	-0.25 ***	0.384
Question 4	-0.18 ***	-0.20 ***	-0.01	-0.11 **	-0.20 ***	0.515
Question 5	-0.06	-0.24 ***	-0.09 *	0.09 *	-0.18 ***	0.317
Question 6	-0.08	-0.21 ***	-0.13 ***	0.02	-0.18 ***	0.361
Question 7	-0.17 ***	-0.14 ***	0.02	-0.07	-0.13 ***	0.301
Question 8	0.03	-0.28 ***	-0.01	-0.01	-0.11 ***	0.170
Question 9	-0.13 **	-0.17 ***	0.01	0.03	-0.20 ***	0.254
Question 10	-0.08	-0.08	-0.01	-0.05	-0.15 ***	0.224
Question 11	-0.03	-0.15 ***	-0.03	-0.10 *	-0.16 ***	0.292
Question 12	-0.07	-0.18 ***	0.02	-0.07	-0.12 ***	0.256
Question 13	-0.03	-0.12 ***	0.07	-0.02	-0.19 ***	0.123
Question 14	-0.05	-0.19 ***	0.05	-0.06	-0.17 ***	0.193
Question 15	0.03	-0.16 ***	0.00	-0.01	-0.16 ***	0.140
Question 16	-0.07	-0.23 ***	-0.03	0.03	-0.13 ***	0.236
Question 17	-0.10	-0.18 ***	-0.01	-0.00	-0.15 ***	0.249
Question 18	-0.10 *	-0.21 ***	-0.07	0.03	-0.10 ***	0.257

Note: Values in the table are the change of WHODAS standardized factors scores by a one-point change of the domain (5 point Likert scale) on the multiple regression models including all domains per question, adjusted for age and gender. p-values are adjusted for false-discovery rate. * p<0.05 ** p<0.01 *** p<0.001

These results confirm the tri-factor results by showing that ability and context are important to predict disability (WHODAS outcome) and demonstrates the potential clinical utility of our psychometric findings.

4. Discussion

We investigated whether adding multiple domains to mental health questionnaires could help better characterize symptoms/behaviors. We found that disability was negatively associated with the domains ability, frequency and context. These results suggest that adding domains such as frequency and context

could help characterize disability besides domains originally probed by the SWAN questionnaire (i.e., ability) and ability and context may add to the clinical utility of frequency phrasing used by most instruments. However, the same relationship was not observed consistently across all outcomes (e.g., between these domains and self-harm), suggesting that domains are differently associated with different outcomes.

Asking people about mental health may be susceptible to cognitive bias such as framing.^{3,4,5} The pursuit of standardizing mental health measurement,^{23,24,25} might benefit from examining the effect of rephrasing a question to assess different aspects of psychopathology beyond frequency. This can be viewed as another degree of complexity for psychopathology measurement, nonetheless important to other needs such as expanding symptom assessment, reliability, invariance among different conditions and other psychometric properties of instruments.²⁵ Here, we present a method to reconstruct the assessment of a given symptom which a clinician or researcher might use by changing the adverbial phrasing and response option. By doing so, for attention and activity symptomatology typical for assessing ADHD, we demonstrate that not only frequency, but ability and context can also additively inform disability. This finding might encourage, for example, assessing these new domains in the World Health Organization Adult ADHD Self-Report Scale,²⁶ a commonly used instrument to assess ADHD, as well as other constructs, such as depression and anxiety.

The association of framing the question as ability, context and frequency were consistent across models and not sensitive to adjustments. In this study, we also applied a factor model (Bauer et al., 2013; Martel et al., 2016) to disentangle the contributions of domains, modeled independently from the general and specific factors of attention and hyperactivity, as well as the specific factor of the questions. The tri-factor model applied in this study confirmed that these specific factors present residual information that contribute to predict disability, independently from the overarching phenomena or questions.

Our search to identify the ‘best domain within a question’ to predict disability revealed that ability and context matter for almost all questions, hence probing for context appears clinically useful in this study (the latter was not probed in the original SWAN questionnaire for measuring ADHD). These results demonstrate the potential clinical utility of our findings in framing mental health questions on attention and activity, by adding domains such as context. Interestingly, this also suggests that context could be uniformly applied to all questions and is more predictive than frequency, which was uniformly not as informative and relevant only to a subset of questions. Importantly, they hint towards potential revision of

ADHD screening in the DSM since currently, all DSM criteria for ADHD are frequency-based. Furthermore, our study highlights the pressing need for questionnaires to be designed with the appropriate domain for each question to best measure outcomes, in contrast to using the same single domain throughout the questionnaire, as seen in most questionnaires. It also indicates that the validated neutral approach to measure both strengths and weaknesses in the same questionnaire like in the SWAN could further be effective by the addition of appropriate domains.

These results must be understood in light of the study's limitations. First, we used the SWAN questionnaire, generally used to probe ADHD and related behaviors. Future directions include investigating whether the results can be generalized to improve the assessment of other types of psychopathology that are frequency reliant or otherwise for other behaviors and questions inferring symptoms from different disorders, and the use of cognitive tasks (such as the two-choice reaction task) to complement survey data. Second, the study sample involved a general population (parent-report on their children of ages 6-17) which was not screened for diagnostic information. Future studies should explore how these findings apply to self-reports and different raters. Moreover, it will be important to understand whether multi-domain approaches could improve diagnostic prediction and whether questions are understood in the same way for different age groups (weak/metric invariance), and whether the structure of the instrument is the same for boys and girls (configural invariance). Concerning the WHODAS results, it may seem as though they resemble a tautology, to the extent that WHODAS does involve ability and context sensitive elements. However, it should be emphasized that the abilities and contexts framed by each question domain (e.g., "How well does your child sustain attention on tasks?") are fundamentally different constructs compared to the general traits measured by WHODAS (e.g., "How much difficulty did your child have in getting along with people?") and the two are not interchangeable. Third, all regressions presented are multiple – however, predictors derived from the tri-factor model were modeled orthogonally. This means that any possible correlation among factors are not due to a shared nature.

5. Conclusion

We tested whether framing psychiatric questions over multiple domains (ability, frequency, duration, intensity, and context) adds predictive value to mental health instruments. For this purpose, we built SWAN+, an enhanced version of SWAN, a mental health questionnaire assessing ADHD symptoms in a positive way, measuring abilities rather than disabilities. In SWAN+, each question became an item assessing 5 distinct domains (ability, frequency, duration, intensity and context). We then evaluated the

extent to which SWAN+ predicts disability and functional outcomes (hospitalization, self-harm and education levels). Our results suggest that the ‘multidomain’ approach to questionnaires may improve inferences and allow for more accurate predictions of mental health and functional outcomes and that specific domains factors may prove reliable and predictive over specific outcomes. Adding multiple domains significantly increases the time burden of testing since it multiplies the amount of queries. Hence, we also investigated which domain within a question best characterizes outcomes such as disability towards smarter survey designs and found clinically relevant results suggesting that context could be a better predictor and could be more uniformly applied compared to frequency in our study. This suggests that framing questions into appropriate and relevant domains is critical for adequately measuring psychopathology, instead of questioning only the frequency or recurrence of any given symptom.

In the future, the methods introduced in this article could allow for shorter, more efficient questionnaires with best indicator questions to infer symptoms, behaviours and psychopathology and improve mental health measurement.

6. Contributions

Conception and experimental design: A.Kr., M.S.H., J.C., J.S., M.M., G.A.S., A.L., A.K.

Data collection and participant coordination: A.Kr., Analytical design and data analysis: G.A.S., M.S.H.

Drafting of the manuscript: A.Kr., M.S.H., F.S. All authors contributed to the interpretation of findings, and the critical review and editing of the document.

7. Acknowledgements

M.S.H is supported by the Newton International Fellowship (Ref: NIF\R1\181942), awarded by the Academy of Medical Sciences through the UK Government's Newton Fund Programme. M.S.H and G.A.S are supported by the US National Institute of Mental Health (grant number R01MH120482).

A. Kr is supported by the IDEFI-IIFR PhD Grant awarded by the University of Paris.

We thank Dr. Barbara Maughan for discussions regarding question phrasing in mental health questionnaires.

8. Statement of conflicts of interest

The authors declare no conflicts of interest.

9. Data availability statement

Supporting data is available at the following public repository: <https://osf.io/rqthx/>

10. References

1. Newson, J. J., Hunter, D., & Thiagarajan, T. C. (2020). The Heterogeneity of Mental Health Assessment. *Frontiers in psychiatry*, 11, 76. <https://doi.org/10.3389/fpsyt.2020.00076>
2. Angold, A., Prendergast, M., Cox, A., Harrington, R., Simonoff, E., & Rutter, M. (1995). The Child and Adolescent Psychiatric Assessment (CAPA). *Psychological Medicine*, 25(4), 739-753. doi:10.1017/S003329170003498X
3. Jingjing Gong, Yan Zhang, Zheng Yang, Yonghua Huang, Jun Feng & Weiwei Zhang (2013) The framing effect in medical decision-making: a review of the literature, *Psychology, Health & Medicine*, 18:6, 645-653, DOI: 10.1080/13548506.2013.766352
4. Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211(4481), 453–458. <https://doi.org/10.1126/science.7455683>
5. Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). All Frames Are Not Created Equal: A Typology and Critical Analysis of Framing Effects. *Organizational Behavior and Human Decision Processes*, 76(2), 149-188. doi:10.1006/obhd.1998.2804
6. Swanson JM, Schuck S, Porter MM, et al. Categorical and Dimensional Definitions and Evaluations of Symptoms of ADHD: History of the SNAP and the SWAN Rating Scales. *Int J Educ Psychol Assess*. 2012;10(1):51–70.
7. Arnett AB, Pennington BF, Friend A, Willcutt EG, Byrne B, Samuelsson S, et al. The SWAN captures variance at the negative and positive ends of the ADHD symptom dimension. *J Atten Disord*. 2013 Feb;17(2):152–62.
8. Young DJ, Levy F, Martin NC, Hay DA. Attention deficit hyperactivity disorder: a Rasch analysis of the SWAN Rating Scale. *Child Psychiatry Hum Dev*. 2009 Dec;40(4):543–59.

9. Alexander LM, Salum G, Swanson JM, Milham MP. Balancing Strengths and Weaknesses in Dimensional Psychiatry. Neuroscience, 2017
10. Gold, Liza H. "DSM-5 and the assessment of functioning: the World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0)." Journal of the American Academy of Psychiatry and the Law Online 42.2 (2014): 173-181.
11. Quickly find research participants you can trust. (n.d.). Retrieved September 23, 2020, from <http://www.prolific.ac/>
12. Palan, S., & Schitter, C. (2018). Prolific.ac—A subject pool for online experiments. Journal of Behavioral and Experimental Finance, 17, 22–27. doi:10.1016/j.jbef.2017.12.004
13. Bauer DJ, Howard AL, Baldasaro RE, et al. A trifactor model for integrating ratings across multiple informants. Psychol Methods. 2013;18(4):475-93.
14. Martel, M. M., Markon, K., & Smith, G. T. (2016). Research Review: Multi-informant integration in child and adolescent psychopathology diagnosis. Journal of Child Psychology and Psychiatry, 58(2), 116–128. doi:10.1111/jcpp.12611
15. Holzinger, K.J. & Swineford, F. Psychometrika (1937) 2: 41.
<https://doi.org/10.1007/BF02287965>
16. Robin X, Turck N, Hainard A, Tiberti N, Lisacek F, Sanchez J-C, et al. pROC: an open-source package for R and S+ to analyze and compare ROC curves. BMC Bioinformatics. 2011 Mar 17;12:77.
17. Hu, L.-t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling, 6(1), 1–55.
<https://doi.org/10.1080/10705519909540118>
18. Raykov, T. (2001). Bias of coefficient alpha for fixed congeneric measures with correlated errors. Applied Psychological Measurement, 25(1), 69–76. doi:10.1177/01466216010251005
19. Rodriguez, A., Reise, S. P., & Haviland, M. G. (2016). Evaluating bifactor models: Calculating and interpreting statistical indices. Psychological Methods, 21(2), 137–150.
<https://doi.org/10.1037/met0000045>
20. Ustun, Tevfik Bedirhan, Kostanjsek, N, Chatterji, S, Rehm, J & World Health Organization. (2010). Measuring health and disability : manual for WHO Disability Assessment Schedule (WHODAS 2.0) / edited by T.B. Üstün, N. Kostanjsek, S. Chatterji, J.Rehm. World Health Organization. <https://apps.who.int/iris/handle/10665/43974>
21. <https://cran.r-project.org/web/packages/finalfit/index.html>

22. Benjamini, Yoav, and Yosef Hochberg. "Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing." Journal of the Royal Statistical Society. Series B (Methodological), vol. 57, no. 1, 1995, pp. 289–300. JSTOR, www.jstor.org/stable/2346101.
23. Farber, G., Dr., Miranda, M., Prof., & Kemmer, D., Dr. (n.d.). Common Measures for Mental Health Science Laying the Foundations June 2020.
24. Wolpert, M., Prof. (n.d.). Funders agree first common metrics for mental health science. Retrieved from <https://www.linkedin.com/pulse/funders-agree-first-common-metrics-mental-health-science-wolpert>
25. Patalay, P., & Fried, E. I. (2020). Editorial Perspective: Prescribing measures: Unintended negative consequences of mandating standardized mental health measurement. Journal of Child Psychology and Psychiatry. doi:10.1111/jcpp.13333
26. Kessler, R. C., Adler, L. A., Gruber, M. J., Sarawate, C. A., Spencer, T., & Brunt, D. L. (2007). Validity of the World Health Organization Adult ADHD Self-Report Scale (ASRS) Screener in a representative sample of health plan members. International Journal of Methods in Psychiatric Research, 16(2), 52-65. doi:10.1002/mpr.208

Supplementary Material:

Table 1: Complete SWAN+ Questionnaire

General Information	
Age of the child	
Gender of the child	Female / Male
Has your child been hospitalised in his/her lifetime?	Yes / No
Has your child engaged in	Yes / No

self harm in his/her lifetime?	
How many years of schooling has your child completed?	
How many years has your child repeated in school?	
SWAN + questions	
1a. How does your child give close attention to detail and avoid careless mistakes compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
1b. How often does your child give close attention to detail and avoid careless mistakes compared to other children?	Never / Rarely / Sometimes / Often / Always
1c. For how long does your child give close attention to detail and avoid careless mistakes compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
1d. How intensely does your child give close attention to detail and avoid careless mistakes compared to other children?	Very little / Little / Moderate / High / Extreme
1e. When does your child give close attention to detail and avoid careless mistakes compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
2a. How does your child sustain attention on tasks or play activities compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average

2b. How often does your child sustain attention on tasks or play activities compared to other children?	Never / Rarely / Sometimes / Often / Always
2c. For how long does your child sustain attention on tasks or play activities compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
2d. How intensely does your child sustain attention on tasks or play activities compared to other children?	Very little / Little / Moderate / High / Extreme
2e. When does your child sustain attention on tasks or play activities compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
3a. How does your child listen when spoken to directly compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
3b. How often does your child listen when spoken to directly compared to other children?	Never / Rarely / Sometimes / Often / Always
3c. For how long does your child listen when spoken to directly compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
3d. How intensely does your child listen when spoken to directly compared to other children?	Very little / Little / Moderate / High / Extreme
3e. When does your child listen when spoken to directly compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations

4a. How does your child follow through on instructions and finish school work and chores compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
4b. How often does your child follow through on instructions and finish school work and chores compared to other children?	Never / Rarely / Sometimes / Often / Always
4c. For how long does your child follow through on instructions and finish school work and chores compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
4d. How intensely does your child follow through on instructions and finish school work and chores compared to other children?	Very little / Little / Moderate / High / Extreme
4e. When does your child follow through on instructions and finish school work and chores compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
5a. How does your child organize tasks and activities compared to other children compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
5b. How often does your child organize tasks and activities compared to other children?	Never / Rarely / Sometimes / Often / Always
5c. For how long does your	Very little time / A little time / A typical amount of time / A long time / A very long time

child organize tasks and activities compared to other children?	
5d. How intensely does your child organize tasks and activities compared to other children?	Very little / Little / Moderate / High / Extreme
5e. When does your child to organize tasks and activities compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
6a. How does your child engage in tasks that require sustained mental effort compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
6b. How often does your child engage in tasks that require sustained mental effort compared to other children?	Never / Rarely / Sometimes / Often / Always
6c. For how long does your child engage in tasks that require sustained mental effort compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
6d. How intensely does your child engage in tasks that require sustained mental effort compared to other children?	Very little / Little / Moderate / High / Extreme
6e. When does your child engage in tasks that require sustained mental effort compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
7a. How does your child keep	Far below average / Slightly below average / Average / Slightly above average / Far above average

track of things necessary for activities (doesn't lose them) compared to other children?	
7b. How often does your child keep track of things necessary for activities (doesn't lose them) compared to other children?	Never / Rarely / Sometimes / Often / Always
7c. For how long does your child keep track of things necessary for activities (doesn't lose them) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
7d. How intensely does your child keep track of things necessary for activities (doesn't lose them) compared to other children?	Very little / Little / Moderate / High / Extreme
7e. When does your child keep track of things necessary for activities (doesn't lose them) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
8a. How does your child ignore extraneous stimuli compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
8b. How often does your child ignore extraneous stimuli compared to other children?	Never / Rarely / Sometimes / Often / Always
8c. For how long does your child ignore extraneous stimuli compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time

8d. How intensely does your child ignore extraneous stimuli compared to other children?	Very little / Little / Moderate / High / Extreme
8e. When does your child ignore extraneous stimuli compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
9a. How does your child remember daily activities compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
9b. How often does your child remember daily activities compared to other children?	Never / Rarely / Sometimes / Often / Always
9c. For how long does your child remember daily activities compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
9d. How intensely does your child remember daily activities compared to other children?	Very little / Little / Moderate / High / Extreme
9e. When does your child remember daily activities compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
10a. How does your child sit still (control movement of hands or feet or control squirming) compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
10b. How often does your child sit still (control movement of hands or feet or controls squirming) compared	Never / Rarely / Sometimes / Often / Always

to other children?	
10c. For how long does your child sit still (control movement of hands or feet or controls squirming) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
10d. How intensely does your child sit still (control movement of hands or feet or controls squirming) compared to other children?	Very little / Little / Moderate / High / Extreme
10e. When does your child sit still (control movement of hands or feet or controls squirming) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
11a. How does your child stay seated (when required by class rules or social conventions compared to other children compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
11b. How often does your child stay seated (when required by class rules or social conventions) compared to other children?	Never / Rarely / Sometimes / Often / Always
11c. For how long does your child stay seated (when required by class rules or social conventions) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
11d. How intensely does your	Very little / Little / Moderate / High / Extreme

child stay seated (when required by class rules or social conventions) compared to other children?	
11e. When does your child stay seated (when required by class rules or social conventions) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
12a. How does your child modulate motor activity (inhibit inappropriate running or climbing) compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
12b. How often does your child modulate motor activity (inhibit inappropriate running or climbing) compared to other children?	Never / Rarely / Sometimes / Often / Always
12c. For how long does your child modulate motor activity (inhibit inappropriate running or climbing) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
12d. How intensely does your child modulate motor activity (inhibit inappropriate running or climbing) compared to other children?	Very little / Little / Moderate / High / Extreme
12e. When does your child modulate motor activity (inhibit inappropriate running or climbing) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations

13a. How does your child play quietly (keep noise level reasonable) compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
13b. How often does your child play quietly (keep noise level reasonable) compared to other children?	Never / Rarely / Sometimes / Often / Always
13c. For how long does your child play quietly (keep noise level reasonable) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
13d. How intensely does your child play quietly (keep noise level reasonable) compared to other children?	Very little / Little / Moderate / High / Extreme
13e. When does your child play quietly (keep noise level reasonable) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
14a. How does your child settle down and rest (control constant activity) compared to other children compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
14b. How often does your child settle down and rest (control constant activity) compared to other children?	Never / Rarely / Sometimes / Often / Always
14c. For how long does your child settle down and rest (control constant activity) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time

14d. How intensely does your child settle down and rest (control constant activity) compared to other children?	Very little / Little / Moderate / High / Extreme
14e. When does your child settle down and rest (control constant activity) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
15a. How does your child modulate verbal activity (control excessive talking) compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
15b. How often does your child modulate verbal activity (control excessive talking) compared to other children?	Never / Rarely / Sometimes / Often / Always
15c. For how long does your child modulate verbal activity (control excessive talking) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
15d. How intensely does your child modulate verbal activity (control excessive talking) compared to other children?	Very little / Little / Moderate / High / Extreme
15e. When does your child modulate verbal activity (control excessive talking) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
16a. How does your child reflect on questions (controls blurting out answers) compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
16b. How often does your	Never / Rarely / Sometimes / Often / Always

child reflect on questions (control blurting out answers) compared to other children?	
16c. For how long does your child reflect on questions (control blurting out answers) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
16d. How intensely does your child reflect on questions (control blurting out answers) compared to other children?	Very little / Little / Moderate / High / Extreme
16e. When does your child reflect on questions (control blurting out answers) compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
17a. How does your child await his/her turn (stand in line and takes turns) compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
17b. How often does your child await his/her turn (stand in line and take turns) compared to other children?	Never / Rarely / Sometimes / Often / Always
17c. For how long does your child await his/her turn (stand in line and take turns) compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
17d. How intensely does your child await his/her turn (stand in line and take turns) compared to other children?	Very little / Little / Moderate / High / Extreme
17e. When does your child await his/her turn (stand in	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations

line and take turns) compared to other children?	
18a. How does your child enter into conversation and games without interrupting or intruding compared to other children?	Far below average / Slightly below average / Average / Slightly above average / Far above average
18b. How often does your child enter into conversation and games without interrupting or intruding compared to other children?	Never / Rarely / Sometimes / Often / Always
18c. For how long does your child enter into conversation and games without interrupting or intruding compared to other children?	Very little time / A little time / A typical amount of time / A long time / A very long time
18d. How intensely does your child enter into conversation and games without interrupting or intruding compared to other children?	Very little / Little / Moderate / High / Extreme
18e. When does your child enter into conversation and games without interrupting or intruding compared to other children?	In any situation / In most situations / In some situations / In a few situations / Only in very specific situations
Getting along with people	<i>In the past 30 days, how much difficulty did your child have in:</i>
Dealing with people he or she does not know?	None / Mild / Moderate / Severe / Extreme or cannot do
Maintaining a friendship?	None / Mild / Moderate / Severe / Extreme or cannot do
Getting along with people	None / Mild / Moderate / Severe / Extreme or cannot do

who are close to him or her?	
Making new friends?	None / Mild / Moderate / Severe / Extreme or cannot do
Life activities	<i>In the past 30 days, how much difficulty did your child have in:</i>
Taking care of his or her household responsibilities?	None / Mild / Moderate / Severe / Extreme or cannot do
Doing his or her most important household tasks well?	None / Mild / Moderate / Severe / Extreme or cannot do
Getting all the household work done that is needed?	None / Mild / Moderate / Severe / Extreme or cannot do
Getting the household work done as quickly as needed?	None / Mild / Moderate / Severe / Extreme or cannot do
His or her day-to-day work/school?	None / Mild / Moderate / Severe / Extreme or cannot do
Doing his or her most important work/school tasks well?	None / Mild / Moderate / Severe / Extreme or cannot do
Getting all the work done that is needed?	None / Mild / Moderate / Severe / Extreme or cannot do
Getting the work done as quickly as needed?	None / Mild / Moderate / Severe / Extreme or cannot do

Supplementary Table 2 - Associations of sum scores of the total scale and domains separately on each outcome, adjusted by age and gender (classical measurement theory approach)

Bivariable models	Hospitalization		Self-harm		Years of schooling		School Fail		Disability (WHODAS factor score)	
	<i>Odds Ratios</i>	<i>95% CI</i>	<i>Odds Ratios</i>	<i>95% CI</i>	<i>Incidence</i>		<i>Odds Ratios</i>	<i>95% CI</i>	β	<i>95% CI</i>
					<i>Rate Ratio</i>	<i>95% CI</i>				
Total score	0.99	0.82 –	0.31**	0.23 –	1.02	0.98 –	0.52*	0.33 –	-0.98*	-1.04 –

		1.20	*	0.42		1.05		0.82	**	-0.92
		0.85 –	0.38**	0.30 –		0.98 –		0.38 –	-0.78*	-0.83 –
Ability	1.00	1.17	*	0.50	1.01	1.04	0.55**	0.81	**	-0.72
		0.79 –	0.29**	0.21 –		0.98 –		0.33 –	-1.00*	-1.06 –
Frequency	0.96	1.17	*	0.40	1.02	1.06	0.53*	0.85	**	-0.93
		0.88 –	0.38**	0.28 –		0.98 –		0.40 –	-0.84*	-0.91 –
Duration	1.05	1.26	*	0.51	1.02	1.05	0.63*	0.99	**	-0.78
		0.86 –	0.38**	0.28 –		0.98 –		0.38 –	-0.87*	-0.94 –
Intensity	1.05	1.27	*	0.52	1.01	1.05	0.61*	0.99	**	-0.80
		0.78 –	0.33**	0.25 –		0.98 –		0.33 –	-0.87*	-0.93 –
Context	0.93	1.11	*	0.44	1.01	1.05	0.49**	0.74	**	-0.81

Note: Predictor scores from 1 to 5. Sum scores are the sum of all items that composes the domain divided by the number of items. Each predictor row represents a regression model, adjusted by age and gender. p-values are adjusted for false-discovery rate. * p<0.05 ** p<0.01 *** p<0.001

Supplementary Table 3 - Multiple regression associations of domain sum scores on each outcome, adjusted by age and gender (classical measurement theory approach)

Predictors	Hospitalization		Self-harm		Years of schooling		School Fail		Disability (WHODAS factor score)	
	<i>Odds Ratios</i>	<i>95% CI</i>	<i>Odds Ratios</i>	<i>95% CI</i>	<i>Incidence Rate Ratio</i>	<i>95% CI</i>	<i>Odds Ratios</i>	<i>95% CI</i>	β	<i>95% CI</i>
		0.64 –		0.23 –		0.94 –		0.12 –		-0.53 –
Ability	0.95	1.40	0.45	0.88	1.01	1.08	0.34	0.92	-0.41***	-0.28
		0.45 –		0.14 –		0.91 –		0.26 –		-0.54 –
Frequency	0.78	1.36	0.36	0.90	1.01	1.12	1.07	4.40	-0.36***	-0.18
		0.85 –		0.74 –		0.92 –		0.59 –		-0.04 –
Duration	1.52	2.72	2.07	5.85	1.03	1.14	2.87	13.86	0.15	0.34
		0.65 –		0.78 –		0.88 –		0.37 –		-0.10 –
Intensity	1.11	1.89	2.10	5.66	0.97	1.07	1.66	7.50	0.07	0.24
		0.55 –		0.27 –		0.93 –		0.16 –		-0.52 –
Context	0.79	1.12	0.47	0.83	1.00	1.06	0.37	0.86	-0.40***	-0.29
Observations	1504		1504		1504		1504		1504	
Tjur's R2	0.007		0.080		0.915		0.016		0.498	

Note: Predictor scores from 1 to 5. Sum scores are the sum of all items that composes the domain divided by the number of items. Each predictor row represents a regression model, adjusted by age and gender. p-values are adjusted for false-discovery rate. * p<0.05 ** p<0.01 *** p<0.001

Supplementary Table 4: Factor loadings of the tri-factor model

Supplementary table 2 - Factor loading of the trifactor model

Items	General factor	Attention	Activity	Domains					Questions
				Ability	Frequency	Duration	Intensity	Context	
Question1_ability	0,548	0,416		0,312					0,474
Question1_frequency	0,544	0,428			0,031				0,504
Question1_duration	0,536	0,465				0,249			0,489
Question1_intensity	0,520	0,482					0,164		0,567
Question1_context	0,479	0,372						0,362	0,375
Question2_ability	0,579	0,416		0,332					0,401
Question2_frequency	0,554	0,423			0,150				0,512
Question2_duration	0,551	0,421				0,127			0,591
Question2_intensity	0,534	0,443					0,170		0,517
Question2_context	0,503	0,384						0,415	0,238
Question3_ability	0,641	0,293		0,271					0,404
Question3_frequency	0,599	0,315			0,302				0,593
Question3_duration	0,697	0,292				0,020			0,477
Question3_intensity	0,631	0,367					0,175		0,479
Question3_context	0,574	0,270						0,347	0,474
Question4_ability	0,605	0,499		0,275					0,401
Question4_frequency	0,599	0,447			0,275				0,528
Question4_duration	0,600	0,526				0,152			0,382
Question4_intensity	0,588	0,547					0,131		0,405
Question4_context	0,552	0,433		0,196				0,356	0,456
Question5_ability	0,547	0,484			0,073				0,433
Question5_frequency	0,524	0,508				0,171			0,576
Question5_duration	0,506	0,472					0,180		0,533
Question5_intensity	0,445	0,522						0,363	0,609
Question5_context	0,472	0,475							0,453
Question6_ability	0,599	0,446		0,318					0,451
Question6_frequency	0,565	0,510			0,005				0,445
Question6_duration	0,597	0,456				0,229			0,485
Question6_intensity	0,537	0,519					0,135		0,533
Question6_context	0,492	0,497						0,358	0,328
Question7_ability	0,572	0,398		0,213					0,530
Question7_frequency	0,574	0,342			0,275				0,604
Question7_duration	0,569	0,372				0,033			0,635
Question7_intensity	0,547	0,383					0,197		0,638
Question7_context	0,531	0,290						0,408	0,525
Question8_ability	0,491	0,223		0,193					0,594
Question8_frequency	0,457	0,127			-0,027				0,772
Question8_duration	0,480	0,153				0,168			0,768
Question8_intensity	0,467	0,139					0,178		0,770
Question8_context	0,404	0,146						0,230	0,598
Question9_ability	0,468	0,424		0,220					0,613
Question9_frequency	0,442	0,389			0,365				0,712
Question9_duration	0,421	0,376				-0,028			0,717
Question9_intensity	0,399	0,396					0,199		0,724
Question9_context	0,408	0,338						0,334	0,613
Question10_ability	0,712		0,126	0,203					0,543
Question10_frequency	0,695		0,220		0,112				0,603
Question10_duration	0,717		0,173			-0,001			0,591
Question10_intensity	0,700		0,101				0,267		0,569
Question10_context	0,630		0,258					0,227	0,551
Question11_ability	0,784		0,073	0,194					0,424
Question11_frequency	0,707		0,182		0,285				0,583
Question11_duration	0,782		0,154			-0,123			0,483
Question11_intensity	0,759		0,093				0,249		0,481
Question11_context	0,658		0,256					0,323	0,443
Question12_ability	0,730		0,101	0,204					0,492
Question12_frequency	0,640		0,218		0,197				0,603
Question12_duration	0,706		0,159			-0,024			0,599
Question12_intensity	0,682		0,169				0,201		0,507
Question12_context	0,639		0,277					0,324	0,482
Question13_ability	0,533		0,358	0,235					0,564
Question13_frequency	0,510		0,362				0,232		0,660
Question13_duration	0,494		0,579					0,177	0,380
Question14_ability	0,648		0,281	0,206					0,503
Question14_frequency	0,578		0,438		0,072				0,547
Question14_duration	0,596		0,417			0,077			0,558
Question14_intensity	0,610		0,389				0,303		0,529
Question14_context	0,526		0,507					0,244	0,390
Question15_ability	0,572		0,205	0,198					0,637
Question15_frequency	0,533		0,349		0,021				0,671
Question15_duration	0,530		0,335			0,225			0,686
Question15_intensity	0,545		0,289				0,259		0,671
Question15_context	0,519		0,404					0,171	0,492
Question16_ability	0,726		0,060	0,191					0,497
Question16_frequency	0,692		0,189		0,091				0,576
Question16_duration	0,653		0,177			0,299			0,581
Question16_intensity	0,676		0,145				0,254		0,578
Question16_context	0,580		0,292					0,303	0,475
Question17_ability	0,653		0,166	0,228					0,567
Question17_frequency	0,605		0,255		0,264				0,688
Question17_duration	0,646		0,218			0,084			0,577
Question17_intensity	0,199		0,149				0,137		0,172
Question17_context	0,546		0,285					0,324	0,575
Question18_ability	0,672		0,101	0,192					0,509
Question18_frequency	0,625		0,145		0,087				0,598
Question18_duration	0,663		0,205			0,207			0,576
Question18_intensity	0,592		0,148				0,268		0,570
Question18_context	0,556		0,250					0,266	0,493

Supplementary table 5 - Reliability indices for each factor of the tri-factor model

	Cronbach's alpha	Omega	Hierarchical Omega
General factor	0.984	0.514	0.804
Attention	0.975	0.342	0.316
Activity	0.975	0.221	0.116
Ability	0.942	0.203	0.105
Frequency	0.924	0.113	0.049
Duration	0.927	0.099	0.025
Intensity	0.921	0.160	0.096
Context	0.931	0.296	0.199
Question 1	0.918	0.374	0.299
Question 2	0.910	0.357	0.267
Question 3	0.925	0.365	0.298
Question 4	0.944	0.285	0.223
Question 5	0.939	0.391	0.328
Question 6	0.934	0.317	0.247
Question 7	0.947	0.432	0.397
Question 8	0.928	0.647	0.612
Question 9	0.947	0.544	0.536
Question 10	0.960	0.406	0.367
Question 11	0.952	0.318	0.271
Question 12	0.947	0.394	0.339
Question 13	0.887	0.379	0.333
Question 14	0.942	0.364	0.300

Question 15	0.948	0.507	0.465
Question 16	0.940	0.396	0.349
Question 17	0.871	0.417	0.374
Question 18	0.925	0.441	0.376

Supplementary Table 6: Multiple regression associations of factors derived from the tri-factor model, adjusted by age and gender, on the study outcomes

<i>Predictors</i>	Hospitalization		Self-harm		Years of schooling		School Fail		Disability (WHODAS factor score)	
	<i>Odds Ratios</i>	<i>95% CI</i>	<i>Odds Ratios</i>	<i>95% CI</i>	<i>Incidence Rate Ratio</i>	<i>95% CI</i>	<i>Odds Ratios</i>	<i>95% CI</i>	β	<i>95% CI</i>
Age	1.02	0.99 – 1.06	1.18***	1.11 – 1.26	1.15***	1.14 – 1.16	1.00	0.91 – 1.10	0.03***	0.02 – 0.05
Male	1.25	1.01 – 1.56	0.52*	0.35 – 0.76	0.99	0.95 – 1.03	1.30	0.71 – 2.38	-0.09*	-0.16 – -0.03
General	1.11	0.94 – 1.30	0.63*	0.47 – 0.84	1.00	0.97 – 1.03	0.70	0.46 – 1.08	-0.49***	-0.54 – -0.44
Attention	0.93	0.75 – 1.14	0.87	0.61 – 1.25	1.01	0.97 – 1.05	1.00	0.58 – 1.72	-0.23***	-0.29 – -0.17
Activity	0.99	0.85 – 1.16	0.99	0.76 – 1.30	1.01	0.98 – 1.04	1.03	0.69 – 1.56	-0.04	-0.09 – 0.01
Ability	0.95	0.82 – 1.08	0.80	0.63 – 1.03	1.01	0.98 – 1.03	0.67	0.46 – 0.97	-0.09***	-0.14 – -0.05
Frequency	0.91	0.77 – 1.07	0.89	0.66 – 1.19	1.01	0.98 – 1.04	0.94	0.62 – 1.43	-0.10***	-0.15 – -0.04
Duration	0.98	0.82 – 1.18	1.30	0.96 – 1.76	1.01	0.97 – 1.04	0.89	0.57 – 1.38	-0.05	-0.11 – 0.00
Intensity	0.99	0.85 – 1.14	1.23	0.93 – 1.63	1.00	0.97 – 1.03	0.92	0.60 – 1.41	0.04	-0.00 – 0.09
Context	0.91	0.80 – 1.04	0.79	0.63 – 0.99	1.00	0.97 – 1.02	0.68	0.49 – 0.94	-0.11***	-0.15 – -0.07
Question 1	1.09	0.91 – 1.32	0.90	0.65 – 1.23	1.00	0.97 – 1.04	0.91	0.56 – 1.47	0.01	-0.05 – 0.06
Question 2	1.01	0.85 – 1.21	0.71	0.52 – 0.98	0.99	0.96 – 1.03	0.88	0.55 – 1.41	0.02	-0.03 – 0.08
Question 3	1.02	0.85 – 1.22	0.80	0.58 – 1.11	0.99	0.96 – 1.03	1.12	0.70 – 1.80	-0.01	-0.06 – 0.05
Question 4	0.99	0.80 – 1.22	0.54*	0.37 – 0.80	0.99	0.96 – 1.03	1.01	0.57 – 1.77	-0.17***	-0.24 – -0.11
Question	1.05	0.87 – 1.05	0.89	0.66 – 1.00	1.00	0.96 – 0.96	0.82	0.52 – 0.82	0.01	-0.04 – 0.07

5		1.26		1.21		1.03		1.31		
Question		0.79 –		0.46 –		0.96 –		0.37 –		
6	0.97	1.19	0.66	0.94	0.99	1.03	0.63	1.08	-0.01	-0.07 – 0.05
Question		0.80 –		0.49 –		0.97 –		0.67 –		
7	0.93	1.09	0.65*	0.86	1.00	1.03	1.02	1.55	-0.00	-0.05 – 0.05
Question		0.84 –		0.76 –		0.98 –		0.72 –		
8	0.96	1.09	0.95	1.19	1.00	1.03	1.00	1.40	0.03	-0.01 – 0.07
Question		0.92 –		0.72 –		0.97 –		0.61 –		
9	1.06	1.23	0.92	1.17	0.99	1.02	0.88	1.28	0.01	-0.04 – 0.05
Question		0.79 –		0.56 –		0.97 –		0.90 –		
10	0.95	1.15	0.78	1.09	1.00	1.04	1.51	2.54	0.02	-0.04 – 0.08
Question		0.74 –		0.50 –		0.97 –		0.44 –		
11	0.92	1.14	0.73	1.07	1.02	1.06	0.80	1.46	0.04	-0.03 – 0.10
Question		0.72 –		0.60 –		0.98 –		0.57 –		
12	0.87	1.04	0.83	1.15	1.01	1.05	0.93	1.51	0.02	-0.03 – 0.08
Question		0.77 –		0.65 –		0.97 –		1.05 –		
13	0.91	1.09	0.86	1.15	1.00	1.03	1.66	2.61	0.09***	0.04 – 0.14
Question		0.82 –		0.55 –		0.97 –		0.85 –		
14	1.00	1.22	0.77	1.07	1.01	1.04	1.42	2.38	0.04	-0.01 – 0.10
Question		0.82 –		0.69 –		0.97 –		0.78 –		
15	0.96	1.13	0.91	1.20	1.00	1.03	1.18	1.79	0.06*	0.01 – 0.11
Question		0.77 –		0.70 –		0.96 –		0.64 –		
16	0.93	1.11	0.97	1.34	1.00	1.03	1.04	1.71	0.06	0.00 – 0.11
Question		0.65 –		0.55 –		0.98 –		0.51 –		
17	0.77	0.92	0.74	1.00	1.01	1.05	0.81	1.28	-0.01	-0.06 – 0.05
Question		0.70 –		0.54 –		0.97 –		0.64 –		
18	0.84	1.00	0.74	1.02	1.00	1.03	1.05	1.73	-0.02	-0.07 – 0.04
Observations	1504			1504		1504		1504		1504
Tjur's R2	0.023			0.108		0.916		0.048		0.567

Note: p-values are adjusted for false-discovery rate. * p<0.05 ** p<0.01 *** p<0.001