Supplementary material for *Are There Distinct Cognitive and Motivational Sub-groups of Children with ADHD?* by Rikke Lambek, Edmund Sonuga-Barke, Rosemary Tannock, Anne Virring Sørensen, Dorte Damm, and Per Hove Thomsen.

**Table S1:** *Measures*

|  |  |
| --- | --- |
| Measure | Description |
| *Tic Tac Toe* (Huizinga *et al.* 2006). | Tic Tac Toe was a computer-based task consisting of two phases (memorization and recognition). During the memorization phase a target pattern of X’s and O’s was presented within a 3x3 grid. The pattern consisted of either three (low memory load) or four (high memory load) letters. During the recognition phase letters were presented one by one at different locations within the grid in series of varying length (three to seven presentations at low load and four to ten at high load). The respondent indicated when the target pattern had been presented by pressing a button. The task included a practice block (5 trials), a low load test block (15 trials), and a high load test block (15 trials). The main dependent variable was mean accuracy (across test trials). |
| *Mental Counters* (Huizinga *et al.* 2006)*.* | Mental Counters was a computer-based task, where the respondent was presented with a target number and instructed to keep track of a series of squares appearing above or below two horizontal lines (counters). The series consisted of either five or seven squares. The respondent was instructed to add 1 to the value of the counter if a square appeared above the line but to subtract 1 if it appeared below the line. The respondent indicated when the counter exceeded the target number by pressing a button. The task included a practice block (5 trials) and a test block (16 trials; 8 with five squares, 8 with seven squares). The main dependent variable was mean accuracy (across test trials). |
| *Finger Windows Backwards* (Bedard & Tannock, 2008). | In the Finger Windows Backwards task, the respondent indicated in the reverse order the sequential placement of a series of asymmetrically located holes previously pointed out by the examiner in a vertically resting card. The task included eight items with an increasing number of holes (from two to nine) and each item included a varying number of trials (from one to six), twenty-eight trials in total. The task was discontinued when three consecutive trials were missed. The main dependent variable was number of correctly recalled trials (i.e., total accuracy). |
| *Local–Global* (Huizinga *et al.* 2006). | In the Local-Global computer-based task, the respondent was first presented with a cue consisting of either two small figures or two large figures (always a square and a rectangle). Then a large target figure (a square or a rectangle) consisting of smaller squares or rectangles was presented. Depending on the cue, the respondent had to respond to either the small figures inside the large target figure (the local dimension) or the large figure itself (the global dimension). The shape of the target also determined the response (i.e., if a small square and a small rectangle were presented as cue and the large target figure consisted of small rectangles then the respondent had to press the button corresponding to the small rectangle). The task consisted of three blocks. In block 1 (30 practice trials; 50 test trials) and 2 (30 practice trials; 50 test trials), the respondent either responded to the local dimension or the global dimension (one block each). In block 3 (40 practice trials; 160 test trials), the respondent alternated between local and global dimensions (i.e., four local trials, four global trials etc.). The main dependent variable was median reaction time (RT) in milliseconds (ms) on alteration trials. |
| *Dots-Triangles* (Huizinga *et al.* 2006). | In the Dots-Triangles computer task a varying number of dots or triangles were presented within a 4x4 grid. There were three blocks. In one block (30 practice trials; 50 test trials) the respondent had to indicate by pressing one of two buttons (left/right) whether more/less dots/triangles were presented in the right or the left half of the grid. In the other block (30 practice trials; 50 test trials) the respondent had to indicate whether more/less dots/triangles were presented in the top or in the bottom half of the grid. A given direction (left/right or top/bottom) was paired with the same figure (dots or triangles) throughout the task. In the last block (40 practice trials, 160 test trials), the respondent alternated between dots and triangles and their designated direction (i.e., four dots trials and four triangle trials). The main dependent variable was median RT in ms on alteration trials. |
| *Trail Making Test* (Reitan, 1971). | The Trail Making Test was a paper-and-pencil task, where the respondent had to alternate between consecutive numbers and letters. A practice trial preceded the test trial. The main dependent variable was total RT in ms. |
| *Flanker Task* (Huyser *et al.* 2011). | In this computer-based arrow version of the Flanker task the respondent was presented with a central cross followed by five arrows. The respondent was instructed to focus on the central arrow. The peripheral arrows (two on each side of the target arrow) pointed either in the same direction as the target arrow (congruent condition) or in the opposite direction (incongruent condition). The respondent was instructed to press one of two buttons (left or right) using their corresponding index finger depending on the direction of the target arrow. The task included one practice block (50 trials) and one test block (100 trials; 50 congruent, 50 incongruent). The main dependent variable was number of correct responses (i.e., total accuracy) on incongruent trials. |
| *Stop-signal task* (Logan, 1994; Logan *et al.* 1997; Williams *et al.* 1999). | In this computer-based Stop-signal task the respondent was instructed to respond every time a letter (an X or an O) was presented on a computer screen (the go signal) and to refrain from responding when a tone (the stop signal) was presented. The task included a practice block and five test blocks each containing thirty-two go signals and eight stop signals. The main dependent variable was stop-signal reaction time (SSRT) in ms calculated by subtracting the mean stop signal delay (the interval between the presentation of the go signal and the stop signal) from the mean reaction time to the go signal (i.e., mean SSRT in ms). |
| *Walk Don’t Walk* from the Test of Everyday Attention of Children (Manly *et al.* 1999). | In this “paper-and-pencil” go/no-go type task the respondent was instructed to progress along a path on a piece of paper by putting a mark with a pen in a square every time one tone was presented (the go signal), but to avoid putting a mark when an alternate tone (the no-go signal) was presented. The task consisted of 4 practice paths and 20 trial paths, each containing 14 squares. The main dependent variable was total number correct responses (i.e., total accuracy). |
| *Choice-Delay Task* (C-DT; Sonuga-Barke *et al.* 1992; Solanto *et al.* 2001). | The C-DT was a computer-based task, where the respondent was required to choose between a green square (which yielded 1 point and a 2-second pre-reward delay) and a blue square (which yielded 2 points and a 30-second pre-reward delay). No post-reward delays were included in the task. The task included 2 practice trials (one of each option) and one test block containing 20 trials. A 4x5 grid with 20 tokens was placed next to the computer and one token removed by the examiner after each trial so the respondent always knew how many trials had been completed and how many remained. At the end of the task the points earned were exchanged for a monetary reward (1 point earned the equivalent of 3,5 Eurocent). The main dependent variable was percentage of choices involving a 1-point reward. |
| Maudsley's Index of Childhood Delay Aversion (MIDA; Kuntsi *et al.* 2001). | The MIDA was a computer-based task where the respondent was required to choose between shooting one spaceship (which yielded one point and a 2-second pre-reward delay) or two spaceships (yielding two points and a 30-second pre-reward delay). Post-reward delays were not included in the task. The task included 2 practice trials (one of each option) and one test block containing 20 trials. A 4x5 grid with 20 tokens was placed next to the computer and one token removed by the examiner after each trial so the respondent always knew how many trials had been completed and how many remained. At the end of the task the points earned were exchanged for stationary items. The main dependent variable was percentage of choices involving a 1-point reward. |
| *Delay Frustration Task* (DeFT; Bitsakou *et al.* 2006). | The DeFT was a computer-based task where the respondent was required to solve a series of multiple choice math questions. The respondent indicated the correct answer by pressing one of four buttons (A, B, C, or D). On the majority of trials (*n* = 39) the subsequent trial began immediately after a response. On sixteen trials the response was followed by a delay (8 trials with delays ranging from 2000 to 10000 ms [i.e., distractor trials] and 8 trials with a delay of 20000 ms). During the delays, the response button was inactive (although all responses were registered). The first response was excluded from analyses as it constituted the response to the math question and not delay aversion. The main dependent variable was the mean total duration of responding per second of delay on the 20000 ms delayed trials. |
| *The Brief Smell Identification Test* (BSIT; Doty, 2001). | The BSIT was a test of olfactory function. The respondent (the child) was presented with a booklet containing 12 microencapsulated odorants. When scratched with the tip of a pencil an odor was released. Each odorant strip included a four-response type multiple choice question and the respondent was instructed to identify the released odor. The child was encouraged to select an odor even if no smell was perceived. The main dependent variable was total number of errors (across test trials). Consequently, a higher score indicated fewer odors identified correctly. |
| *Background questionnaire* | The background questionnaire queried parents about their highest completed education. Based on this information a score was calculated (education in years; possible range 0-17.5 years) for each parent (mother and father). The highest education score in each “family unit” (i.e., belonging to the mother or the father) was included in the present study as a proxy for the child’s socioeconomic status. |
| *Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale* (SWAN; Swanson *et al.* 2001). | The SWAN was a questionnaire asking parents and teachers to assess 18 DSM ADHD congruent symptoms in their child/student based on observations within the last month. The answer possibilities ranged from “Far below average” (+3) to “Far above average” (-3). In the present study, the main dependent variables from the SWAN were mean scores on the Inattention and Hyperactivity/impulsivity scales. Scores on both versions of the SWAN were found to have good to excellent internal consistency in the present sample (SWAN parent version: *α*Inattention = .869 [ADHD group], .906 [TD group]; *α*Hyperactivity/impulsivity = .895 [ADHD group], .937 [TD group] and SWAN teacher version: *α*Inattention =.837 [ADHD group], .971 [TD group]; *α*Hyperactivity/impulsivity =.897 [ADHD group], .968 [TD group]). |
| *The Behavior Rating Inventory of Executive Function* (BRIEF; Gioia *et al.* 2000). | The BRIEF was a questionnaire asking parents and teachers to assess 86 items about behaviors relating to executive functioning in their child/student based on observations within the last 6 months. The answer possibilities ranged from “Never” to ”Often”. The BRIEF comprised a number of scales. In the present study, the main dependent variables were mean scores on the Working memory, Shift, and Inhibit scales. Scores on both versions of the BRIEF were found to have acceptable to excellent internal consistency in the present sample (BRIEF parent version: *α*Working memory = .864 [ADHD group], .898 [TD group]; *α*Shift = .815 [ADHD group], .792 ([TD group]; *α*Inhibit = .863 [ADHD group], .839 ([TD group] and BRIEF teacher version: *α*Working memory = .864 [ADHD group], .939 [TD group]; *α*Shift = .863 [ADHD group], .930 ([TD group]; *α*Inhibit = .879 [ADHD group], .935 ([TD group]). |

*α* = Cronbach alpha; TD = Typically developing.

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**Table S2:** *Correlations between BRIEF scales and executive function tasks*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ADHD | | | | | | TD | | | | | |
|  | BRIEF scales | | | | | | BRIEF scales | | | | | |
|  | Parent-reports | | | Teacher-reportsa | | | Parent-reports | | | Teacher-reportsa | | |
| Tasks | WM | SH | IN | WM | SH | IN | WM | SH | IN | WM | SH | IN |
| Tic Tac Toe  (Mean accuracy) | -.078 | -.223\* | -.261\*\* | -.127 | -.054 | -.075 | -.161 | -.202\* | -.161 | .126 | .084 | .026 |
| Mental Counters  (Mean accuracy) | .043 | -.159 | -.229\* | -.099 | .001 | -.104 | -.109 | -.143 | -.158 | -.089 | -.168 | -.222 |
| Finger Windows Backwards (Total accuracy) | -.038 | -.131 | -.195 | -.126 | -.051 | -.142 | -.249\* | -.237\* | -.313\*\* | -.102 | -.259 | -.210 |
| Local–Global  (Median RT; ms) | .048 | -.008 | -.049 | -.085 | -.187 | -.118 | -.185 | -.176 | -.172 | -.171 | -.080 | -.145 |
| Dots–Triangles  (Median RT; ms) | -.204 | .048 | -.009 | -.135 | .031 | .110 | -.139 | -.176 | -.151 | -.326\* | -.224 | -.250 |
| Trail Making Test  (Total RT; ms) | -.054 | -.170 | -.063 | -.045 | -.092 | .001 | -.162 | -.159 | -.227\* | -.141 | -.181 | -.344\* |
| Flanker Task  (IT total accuracy) | -.079 | -.182 | -.222\* | -.230\* | .040 | -.195 | -.174 | -.398\*\* | -.204\* | -.223 | -.243 | -.292 |
| Stop-signal task  (Mean SSRT; ms) | .030 | -.007 | -.129 | -.020 | -.013 | -.106 | -.269\*\* | -.034 | -.267\*\* | -.133 | -.049 | -.209 |
| TEA-Ch  (Walk don’t Walk total accuracy) | -.083 | .047 | -.193 | -.252\* | .100 | -.198 | -.168 | -.225\* | -.095 | -.183 | -.186 | -.231 |

BRIEF = Behavior Rating Inventory of Executive Function; IN = Inhibit; IT = Incongruent trials; ms = millisecond; RT = reaction time; SH = Shift; SSRT = Stop-signal reaction time; TD = TD = typically developing; TEA-Ch = Test of Everyday Attention for Children; WM = Working memory. aMissing teacher questionnaires (9 in ADHD group; 50 in TD group).

*\*p* < .05; \*\**p* < .01.

**Figure S3:** *CFA**models 1-6*

**Model 1**

WM1

WM2

WM3

SH1

SH2

SH3

IN1

IN2

IN3

DA1

DA2

**Model 2**

WM22

WM33

SH1

SH2

SH3

IN1

IN2

IN3

WM1

DA1

DA2

**Model 3**

DA1

DA2

WM2

WM3

SH1

SH2

SH3

IN1

IN2

IN3

WM1

DA1

DA2

**Model 4**

DA1

DA2

WM1

WM2

WM3

SH1

SH2

SH3

IN1

IN2

IN3

**Model 5**

SH1

SH2

SH3

IN1

IN2

IN3

WM1

WM2

WM3

DA1

DA2

**Model 6**

WM1 = Tic Tac Toe; WM2 = Mental Counters; WM3 = Finger Windows Backwards; SH1 = Local–Global; SH2 = Dots–Triangles; SH3 = Trail Making Test; IN1 = Flanker Task; IN2 = Stop-signal task; IN3 = Walk Don’t Walk from Test of Everyday Attention for Children; DA1 = Choice-Delay Task; DA2 = Maudsley's Index of Childhood Delay Aversion.

WM1

WM2

WM3

SH1

SH2

SH3

IN1

IN2

IN3

DA1

DA2

**Table S4.** *Fit statistics for the CFA for typically developing children*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Modela | χ2 (df) *p* | CFI | TLI | RMSEA (90% CI) | SRMR | AIC | BIC |
| 1 | 61.470 (44) .042 | .918 | .897 | .064 (.013-.100) | .062 | 8103.649 | 8188.273 |
| 2 | 56.829 (43) .077 | .935 | .917 | .058 (.000-.095) | .058 | 8101.006 | 8188.194 |
| 3 | 54.511 (41) .077 | .936 | .915 | .059 (.000-.097) | .056 | 8102.098 | 8194.414 |
| 4 | 43.445 (41) .368 | .989 | .985 | .025 (.000-.076) | .056 | 8090.636 | 8182.953 |
| 5 | 56.278 (41) .056 | .928 | .904 | .062 (.000-.100) | .057 | 8103.089 | 8195.405 |
| 6 | 42.026 (38) .301 | .981 | .973 | .033 (.000-.081) | .054 | 8094.418 | 8194.427 |

AIC= Akaike information criterion; BIC = Bayesian information criterion; χ2 = Chi-square; CFI = comparative fit index; CI = confidence interval; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; TLI = Tucker Lewis index.

aModel 1 = One factor - common neuropsychological function; Model 2 = Two factors - executive function and delay aversion; Model 3 = Three factors - working memory/shifting, inhibition, and delay aversion; Model 4 = Three factors - working memory/inhibition, shifting, and delay aversion; Model 5 = Three factors - working memory, shifting/inhibition, and delay aversion; Model 6 = Four factors - working memory, shifting, inhibition, and delay aversion.

**Table S5.** *Factor loadings (standard error) and factor correlations (standard error) for Model 4 for typically developing children*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Working Memory/  Inhibition | Shifting | Delay Aversion |
| Tic Tac Toe (Mean accuracy) | .594 (.080) |  |  |
| Mental Counters (Mean accuracy) | .584 (.088) |  |  |
| Finger Windows Backwards (Total accuracy) | .652 (.077) |  |  |
| Local–Global (Median RT; ms) |  | .846 (.083) |  |
| Dots–Triangles (Median RT; ms) |  | .659 (.094) |  |
| Trail Making Test (Total RT; ms) |  | .519 (.126) |  |
| Flanker Task (IT total accuracy) | .655 (.068) |  |  |
| Stop-signal task (Mean SSRT; ms) | .605 (.085) |  |  |
| TEA-Ch (Walk don’t Walk total accuracy) | .656 (.071) |  |  |
| Choice-Delay Task (% short small rewards) |  |  | .503 (.169) |
| Maudsley’s index of Childhood DAv (% short small rewards) | . |  | .577 (.153) |
| Working Memory/Inhibition | 1.00 |  |  |
| Shifting | .676 (.109) | 1.00 |  |
| Delay Aversion | .575 (.146) | .365 (.120) | 1.00 |

DAv = delay aversion; IT = Incongruent trials; ms = millisecond; RT = reaction time; SSRT = Stop-signal reaction time; TEA-Ch = Test of Everyday Attention for Children.

**Table S6.** *Fit statistics for the LPA with covariates age, SES, and IQ for typically developing children*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | LRχ2 | AIC | BIC | Entropy | LMR-A (*p*) |
| 2 | -254.000 | 534.000 | 567.336 | .972 | 204.738 (.000) |
| 3 | -221.465 | 482.931 | 534.218 | .933 | 67.773 (.010) |
| 4 | -212.143 | 478.286 | 547.524 | .924 | 18.079 (.150) |
| 5 | -194.354 | 456.709 | 543.896 | .928 | 24.279 (.240) |
| 6 | -182.408 | 446.816 | 551.955 | .948 | 32.908 (.079) |

LRχ2 = the likelihood ratio chi-square; AIC= Akaike information criterion; BIC = Bayesian information criterion; LMR-A = Lo-Mendell-Rubins adjusted likelihood ratio test.

**Table S7.**Class comparisons

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ADHD | | | | | TD | | | | |
| Variables | Classa | Mean (SD)/  *n* (%) | *F*3,96/  χ23,100 | 2/ V | Post hoc tests  (*p* < .05)b | Classa | Mean (SD) | *F*2,93 | 2 | Post hoc tests  (*p* < .05)b |
| DAWBA |  |  |  |  |  |  |  |  |  |  |
| Externalising  disordersc | 1  2  3  4 | 8 (25.000)  10 (28.571)  10 (38.462)  4 (57.143) | 3.442 | .19 | n/a | - | - | - | - | - |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Internalising  disordersc | 1  2  3  4 | 6 (18.750)  9 (25.714)  5 (19.231)  3 (42.857) | 2.239 | .15 | n/a | - | - | - | - | - |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SWAN |  |  |  |  |  |  |  |  |  |  |
| Parent-report  Inattention | 1  2  3  4 | 1.139 (.718)  1.752 (.661)  1.453 (.619)  1.635 (.590) | 4.891\*\* | .13 | **2>1** | 1  2  3 | -.608 (.866)  -.530 (.790)  -.185 (.680) | 2.368 | .05 | n/a |
| Parent-report  Hyperactivity/  impulsivity | 1  2  3  4 | .875 (.682)  1.177 (.836)  1.584 (.745)  1.270 (.672) | 4.246\*\* | .12 | **3>1**,2 | 1  2  3 | -.582 (.936)  -.552 (.779)  -.531 (.866) | .027 | <.01 | n/a |
| Teacher-report  Inattentionc | 1  2  3  4 | 1.594 (.684)  1.701 (.598)  1.908 (.775)  1.825 (.155) | 1.050 | .03 | n/a | 1  2  3 | -.701 (1.367)  -.680 (1.111)  -.633 (1.460) | .010 | <.01 | n/a |
| Teacher-report  Hyperactivity/  impulsivityc | 1  2  3  4 | 1.184 (.625)  1.205 (.841)  1.761 (.895)  1.762 (.901) | 3.381\* | .10 | 3>1,2 | 1  2  3 | -1.021 (1.045)  -.948 (1.038)  -1.359 (1.579) | .461 | .02 | n/a |
| BRIEF |  |  |  |  |  |  |  |  |  |  |
| Parent-report  Working  memory | 1  2  3  4 | 2.294 (.372)  2.468 (.449)  2.446 (.365)  2.486 (.449) | 1.271 | .04 | n/a | 1  2  3 | 1.371 (.335)  1.537 (.425)  1.652 (.489) | 3.561\* | .07 | **3>1** |
| Parent-report  Shift | 1  2  3  4 | 1.965 (.383)  1.949 (.512)  2.245 (.417)  2.311 (.347) | 3.555\* | .10 | 3>1  3,4>2 | 1  2  3 | 1.151 (.140)  1.296 (.320)  1.366 (.395) | 4.277\* | .08 | 2,**3>1** |
| Parent-report  Inhibit | 1  2  3  4 | 1.988 (.363)  2.057 (.514)  2.455 (.361)  2.284 (.562) | 6.476\*\*\* | .17 | **3>1**,**2** | 1  2  3 | 1.221 (.300)  1.283 (.238)  1.374 (.394) | 1.848 | .04 | n/a |
| Teacher-report  Working  memory | 1  2  3  4 | 2.238 (.390)  2.433 (.344)  2.522 (.452)  2.543 (.190) | 2.943\* | .09 | 2,3>1 | 1  2  3 | 1.363 (.324)  1.277 (.395)  1.369 (.585) | .224 | .01 | n/a |
| Teacher-report  Shiftc | 1  2  3  4 | 2.162 (.416)  2.185 (.481)  2.292 (.477)  2.386 (.414) | .720 | .02 | n/a | 1  2  3 | 1.132 (.250)  1.188 (.291)  1.271 (.462) | .615 | .03 | n/a |
| Teacher-report  Inhibitd | 1  2  3  4 | 2.256 (.453)  2.282 (.474)  2.504 (.469)  2.471 (.670) | 1.507 | .05 | n/a | 1  2  3 | 1.094 (.157)  1.165 (.271)  1.292 (.544) | 1.207 | .05 | n/a |
| BSITe  Errors | 1  2  3  4 | 1.935 (1.611)  2.059 (1.969)  3.231 (1.531)  4.000 (2.380) | 4.835\*\* | .13 | **3**,**4>1**,2 | 1  2  3 | 1.206 (1.149)  1.800 (1.232)  2.444 (1.672) | 6.409\*\* | .12 | **3>1** |

BRIEF = Behavior Rating Inventory of Executive Function; BSIT = The Brief SmellIdentification Test; DAWBA = Development and Well-Being Assessment; Externalising disorders = conduct disorder, oppositional defiant disorder; Internalising disorders = specific phobia, social phobia, obsessive-compulsive disorder, generalized anxiety disorder, separation anxiety disorder, anxiety disorder NOS, depression, depressive disorder NOS; SWAN = Strengths and Weaknesses of ADHD-Symptoms and Normal-Behavior; TD = typically developing; V = Cramer’s V.

aClass 1= High performers; Class 2 = Average performers; Class 3 = Low performers; Class 4 = Very low performers. bBolded numbers denote statistically significant differences after Bonferroni correction. cDue to cells with expected count less than 5, analyses were rerun using Fisher’s exact test with similar non-significant results. dMissing teacher questionnaires (9 in ADHD group; 50 in TD group). eMissing BSIT (2 in ADHD group).

\**p* < .05; \*\**p* < .01; \*\*\**p* < .001.