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NEPS TECHNICAL REPORT FOR ATTENTION: ADMINISTRATION OF THE FRANKFURT ATTENTION INVENTORY (FAIR) IN STARTING COHORT 4 (GRADE 9) FOR STUDENTS WITH SPECIAL EDUCATIONAL NEEDS

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NEPS Technical Report for Attention: Administration of the Frankfurt Attention Inventory (FAIR) in Starting Cohort 4 (Grade 9) for Students with Special Educational Needs

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Abstract

The National Educational Panel Study (NEPS) investigates the development of competencies across the life span. This paper describes the Frankfurt Attention Inventory (FAIR) that was administered in grade 9 of Starting Cohort 4 (ninth grade) to students at special schools. Descriptive analyses showed rather poor test performance for these students. Moreover, quality indices indicated that a substantial proportion of students seemed to have difficulties understanding and following the test instruction. Thus, in applied research FAIR test scores provided in the Scientific Use File should only be used for a subsample of students at special schools.

Keywords

Content

1. Introduction

Within the National Educational Panel Study (NEPS) different domain-specific competences are measured coherently across the life span. These include, among others, reading competence, mathematical competence, scientific literacy, information and communication technologies literacy, metacognition, vocabulary, and domain general cognitive functioning. An overview of the competences measured in the NEPS is given by Weinert and colleagues (2011) as well as Fuß, Gnambs, Lockl, and Attig (2019). In addition, various domain-overlapping cognitive abilities are measured in different starting cohorts. In Starting Cohort 4 an attention measure was administered to students at special schools. In this paper, the test material and assessment procedure are presented and several indicators of students' attentional capacity that are derived from this measure are introduced. Finally, an overview of the data that is available for public use in the scientific use file (SUF) is presented.

Please note that the analyses in this report are based on the data available at some time before public data release. Due to ongoing data protection and data cleansing issues, the data in the SUF may differ slightly from the data used for the analyses in this paper. However, fundamental changes in the presented results are not expected.

2. The Frankfurt Attention Inventory (FAIR)

The *Frankfurt Attention Inventory* (FAIR; Moosbrugger & Oehlschlägel, 1996) measures test takers' directed attention, that is, their ability to quickly discriminate similar information and ignore task-irrelevant stimuli. The FAIR is a paper-based test that requires test takers to identify target stimuli within a short time frame. The test includes two types of items: The target stimuli (see first row of Figure 1) are circles with three dots and squares with two dots. The remaining items represent distractors (see second row of Figure 1) including circles with two dots and squares with three dots. The test includes 640 items presented on two pages including 320 items each. On each page the items were presented in a matrix structure including 16 rows and 20 columns. The time limit for each page was 3 minutes.
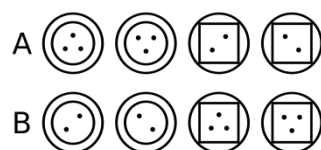
Figure 1. Target stimuli (A) and distractors (B) for the FAIR.

The test takers were instructed to identify the target stimuli in each row by drawing a continuous line below the distractors and a spike at each target stimulus (see Figure 2). This procedure guaranteed that test takers had to evaluate each item one after another and did not repeat a given item.
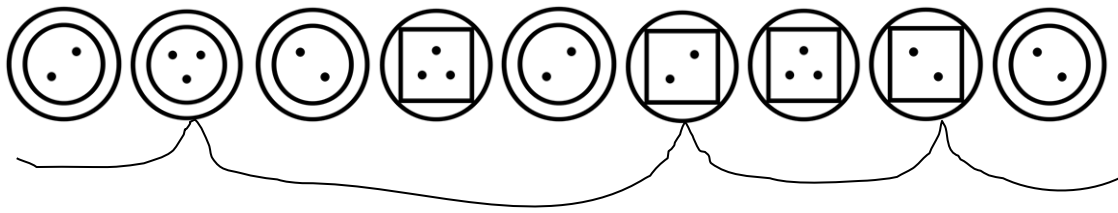
Figure 2. A correct response line for an item of the FAIR.

Four different types of responses can be distinguished for each item:

- **Correct response**: The target stimulus is correctly marked with a spike or the distractor is not marked (see Figure 2).

- **Line error (F_L)**: The continuous line is incorrect because no line was drawn below the stimulus (*omission*; Figure 3), more than one line was drawn for the stimulus (*multiple marking*; Figure 4), or the continuous line was interrupted (*single marking*; Figure 5).
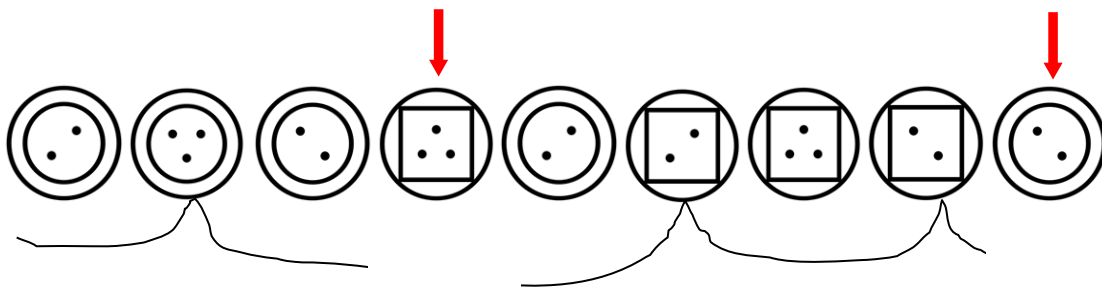
Figure 3. Example of an omission error.
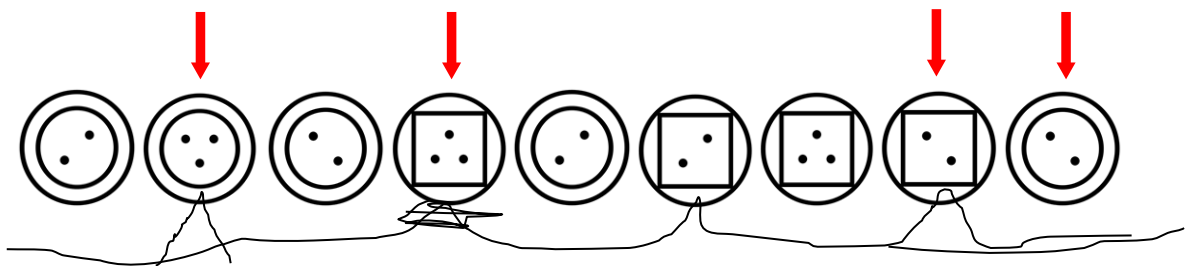
Figure 4. Example of a line error with multiple markings.
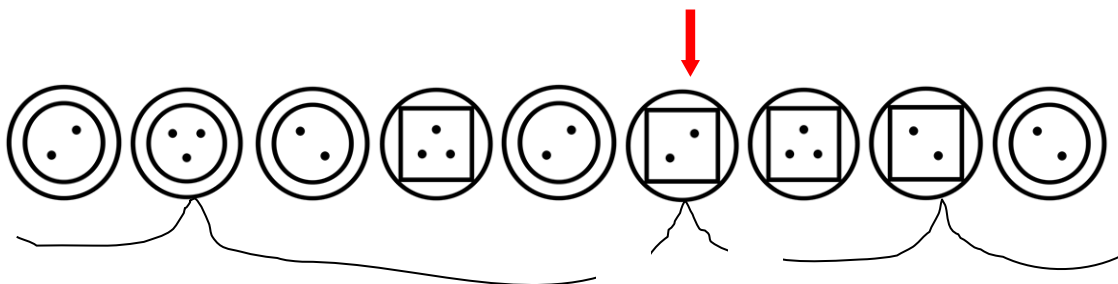
Figure 5. Example of a line error with single marking.

- **Miss error (F_V)**: A target stimulus is not marked with a spike.

- **False alarm (F_A)**: A distractor is marked with a spike.

- **Supplement error (F_Z)**: Test takers are instructed to identify two target stimuli. However, if a test taker did not adhere to the instruction and focused on only one target stimulus, this type of error can be identified by counting the number of successive errors of the same type. In case the sequence of errors made by a test taker includes at least five successive errors of the same type, each of these errors is counted as a supplement error. For example, the error sequence a-b-b-b-b-b-b-a-c-b-c-c-c-c-c-a (each letter represents one of the three errors described above) results in 11 supplement errors resulting from the sequence b-b-b-b-b-b (6) and the sequence c-c-c-c-c (5).

For the scoring of the FAIR, the number of line errors F_L, the number of miss errors F_V, the number of false alarms F_A, and the number of supplement errors F_Z are counted. In addition, the total number of marked stimuli G (including potential errors) is counted, that is, the last item on each page marked with a spike or a continuous line below is identified and summed across the two pages. From these values a number of measures are calculated to evaluate the attention capacity of the test takers:

1. **Marker value M** (*Markierungswert*): The marker value (see equation 1) is used to evaluate whether the test result can be properly interpreted at all for the test taker. The test authors advise against interpreting test results of the FAIR for test takers with a M falling below 0.95 (Moosbrugger & Oehlschläger, 1996); in some situations, lower thresholds have also been used (e.g., 0.91; Walter, 2012).

$$M = \frac{G - F_L}{G} \qquad (1)$$

2. **Achievement value L** (*Leistungswert*): The achievement value (see equation 2) is calculated by subtracting all errors from the number of marked stimuli. Miss errors and false alarms are counted twice because it can be expected that test takers randomly respond correctly about half of the time even when working on the test while paying little attention.

$$L = \left(G - F_L\right) - 2 \cdot \left(F_V + F_A\right) \qquad (2)$$

3. **Quality value Q** (*Qualitätswert*): The quality value (see equation 3) is a normalization of L to highlight the degree of attention relative to the stimuli completed by the test taker. However, this measure does not take the number of marked items into account.

$$Q = \frac{L}{G} \qquad (3)$$

4. **Continuity value *K*** (*Kontinuitätswert*): The continuity value (see equation 4) informs whether a test taker showed sustained attention. It has the disadvantage that in the case of a negative *L* it will take a positive value (in contrast to *Q* which will also be negative). A given value of *K* might therefore correspond to different values of *L* and *Q* and different attention levels. Further information on the interpretation of *K* is given in Turß (2002) and the test manual (Moosbrugger & Oehlschlägel, 1996).

$$K = Q \cdot L \tag{4}$$

If supplement errors that reflect test taker's adherence to the instruction are taken into account, *L* and, as a consequence, also *Q* and *K* need to be modified following equations 5 to 7.

$$L^* = \left(G - F_L\right) - 2 \cdot \left(F_V + F_A + F_Z\right) \tag{5}$$

$$Q^* = \frac{L^*}{G} \tag{6}$$

$$K^* = Q^* \cdot L^* \tag{7}$$

The indicators *L* and *Q* reflect different aspects of concentration. Whereas *L* indicates the degree of cognitive resources that were used for concentrated work, *Q* reflects a form of a cognitive self-control process that aims to minimize periods of inattention. Both aspects are components of attention and, thus, are reflected in *K*. Therefore, the predictive validity of *K* is expected to be higher as compared to *L* or *Q* (Moosbrugger & Oehlschlägel, 1996).

3. FAIR Test Performance among Students at Special Schools

In grade nine of Starting Cohort 4, a total of *N* = 1,014 students (45% female) attending special schools for students with educational needs in the area of learning were administered the FAIR (Version A; Moosbrugger & Oehlschlägel, 1996). Table 1 summarizes the error types made by the students. These results highlight that some test takers provided few correct responses and produced many errors. However, most students made only few errors resulting in a median number of *Mdn* = 119 correct responses. Most mistakes were line errors (*Mdn* = 10); miss errors (*Mdn* = 9), and supplement errors (*Mdn* = 6); in contrast, false alarms (*Mdn* = 4) were rare.

Another indication of the response quality is given by the marking value *M* (see Table 2) that should exceed 0.95 for meaningful interpretations of FAIR test performance (see Moosbrugger & Oehlschläger, 1996). However, many test takers (39% of all students) had values of *M* below this threshold. Therefore, many students were unable to properly follow the test instruction resulting in many line errors. According to the test developers, these cases should not be included in research on substantial research questions using the FAIR. Alternatively, since these students might be of interest to specific research questions, it could be evaluated whether other thresholds for *M* can be justified. For example, for a threshold of 0.91 (cf. Walter, 2012) more than 80% of the students would have been classified as acceptable. However, it should be emphasized that lower values of *M* could be problematic as low values reflect students' inability to understand the general concept of the test.

Table 1

Descriptive Information on FAIR Error Types

	G	F_L	F_V	F_A	F_Z	Correct
M	284	18	25	14	20	121
Mdn	273	10	9	4	6	119
SD	109	32	40	27	40	50
Min	40	0	0	0	9	0
Max	640	564	253	180	564	361

Table 2

Descriptive Information on FAIR Test Performance

	M	L	Q	K	L*	Q*	K*
M	0.94	203	0.73	182	179	0.66	177
Mdn	0.96	221	0.89	197	213	0.86	187
SD	0.09	120	0.34	110	149	0.45	107
Min	0.00	-317	-0.84	0.00	-445	-1.03	0.00
Max	1.00	613	1.00	587	613	1.00	587

Note. M is based on the overall sample of N = 1,014 students, whereas the remaining indices were limited to cases with $M \geq 0.95$ (N = 621).

Information on the test performance in the FAIR for students with $M \geq 0.95$ is summarized in Table 2. Generally, students at special schools performed rather poorly. About 6.4% of them produced a large amount of errors that resulted in negative values of L and Q. If supplement errors are taken into account, even 14.2% of the students had negative values of $L*$ and $Q*$. K or $K*$ should not be interpreted for these cases. The median K for this subsample of students with special educational needs fell at the 16th percentile of the respective norm sample of 14 to 17 year old adolescents (Moosbrugger & Oehlschläger, 1996). Given the large proportion of students with $M < 0.95$ and a negative L and Q (which are not explicitly considered by the test authors), students at special schools seemed to have pronounced difficulties with the test.

4. Data in the Scientific Use File

The SUF contains 640 variables for the administered items. Items 1 to 320 were presented on the first page, whereas the remaining items were printed on a second page. These stimuli were scored as "not marked" (1), "marked" (2), or "line error" (3). In addition, fag9anz1 and fag9anz2 give the total number of marked stimuli on each page. These variables were used to calculate the number of line errors F_L (fag900fl), miss errors F_V (fag900fv), false alarms (fag900fa), and supplement errors F_Z (fag900fz) for each person. The number of marked stimuli G is given in fag9000g. From these variables the marking value M (fag9000m), achievement value L (fag9000l), quality value Q (fag9000q), and the continuity value K (fag9000k) were derived as described above. Moreover, fag900ls, fag900qs, and fag900ks give the adjusted values that also acknowledged supplement errors. The R syntax for calculating these indices is given in the appendix.

Please note that some values of the (adjusted) achievement values L and L^* available in fag9000l and fag900ls were in conflict with the coding scheme of missing values used in the NEPS. For example, a negative achievement value of -52 in fag9000l would correspond to the missing definition of an "implausible value". Therefore, all achievement values in fag9000l and fag900ls were divided by 100. This does not affect statistical analyses conducted with these scores. Users that prefer to work with achievement values in their original metric (as defined by the test authors; Moosbrugger & Oehlschläger, 1996) need to multiply the respective variables with 100.

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Appendix: R Syntax for Calculating FAIR Scores

```
# Load packages
library(dplyr)
library(haven)

# Load data
dat <- read_spss('SC4_xTargetSpecialNeedsCompetencies_D_10-0-0.sav')

# Items of the FAIR
items <- paste0("fag9", formatC(1:640, width = 4, format = "d", flag = 0))

# Select variables
dat <- select(dat, ID_t, one_of(items), fag9anz1, fag9anz2)

# Type for each item (4 types)
# note: 1/4 = target stimuli, 2/3 = distractor
#       1 (square with 2 dots), 2 (square with 3 dots),
#       3 (circle with 2 dots), 4 (circle with 3 dots)
types <- c(1,2,1,3,3,1,1,4,3,4,4,2,2,3,2,4,4,3,1,3,
           2,2,4,2,1,1,4,1,2,3,3,4,1,3,2,4,4,2,3,3,
           4,3,1,1,2,2,1,4,2,3,2,2,1,4,3,3,4,4,1,1,
           3,1,2,4,4,1,3,4,3,3,1,4,2,1,1,2,3,2,2,4,
           3,2,4,3,1,4,4,2,1,1,3,4,1,2,2,3,2,2,4,4,
           2,1,2,3,3,1,4,1,1,3,4,3,4,2,1,4,3,2,2,4,
           4,1,2,3,3,1,1,3,1,1,4,3,4,4,1,2,1,3,3,2,
           4,2,2,3,3,4,3,2,4,4,2,2,1,2,3,1,1,4,1,3,
           2,4,4,1,3,3,4,2,1,1,4,3,2,3,1,2,2,1,1,4,
           3,3,2,4,4,2,3,1,3,4,1,2,2,4,3,4,4,2,3,3,
           2,1,3,1,1,4,1,2,2,3,3,4,1,3,2,4,4,3,1,2,
           1,1,4,2,4,4,2,1,1,4,1,3,1,2,2,3,4,3,3,2,
           2,1,1,3,3,4,3,2,4,4,2,2,3,1,4,1,3,1,1,2,
           4,4,1,4,3,3,4,2,2,3,2,1,1,2,4,4,1,3,4,2,
           2,3,2,1,4,3,3,1,1,3,3,2,1,2,3,1,4,3,4,4,
           2,2,4,1,3,2,1,4,2,2,4,4,1,1,2,3,4,3,3,1,
           2,3,1,3,3,2,1,4,3,4,4,1,1,2,2,4,4,1,4,3,
           3,4,2,3,2,1,3,1,1,2,2,4,3,4,4,2,3,2,1,2,
           2,4,1,3,3,1,1,4,4,3,3,2,3,1,2,4,1,3,4,2,
           2,1,1,4,3,1,3,2,3,3,4,4,2,1,1,2,2,4,1,4,
           2,4,3,3,1,4,4,1,2,1,1,3,4,2,2,3,1,1,4,3,
           2,2,4,2,1,2,3,3,4,4,1,3,2,2,4,2,1,1,3,4,
           1,4,4,3,1,2,3,3,2,4,2,2,3,1,4,3,3,4,4,1,
           2,1,1,3,1,1,4,3,3,2,2,3,4,4,1,2,4,2,1,3,
           3,3,4,4,3,2,1,1,4,2,2,4,1,3,1,2,3,1,4,1,
           1,2,1,3,4,2,2,4,4,3,3,2,3,3,4,3,1,4,2,4,
           4,1,3,2,2,1,1,2,4,4,2,2,3,4,3,2,1,3,3,1,
           4,1,1,2,3,4,4,1,3,1,1,4,2,2,1,2,4,3,3,2,
           3,1,2,4,2,3,3,4,4,3,2,2,1,4,1,1,2,3,2,2,
           4,3,3,4,4,1,3,1,4,2,1,1,4,2,3,2,2,1,3,3,
           1,1,2,4,3,4,4,1,2,3,1,3,2,2,1,4,4,3,3,4,
           2,4,1,1,4,4,3,2,2,3,3,4,1,1,2,4,2,1,3,1)
```

```
#
# Number of errors for each respondent
#


# Line error FL
dat$fag900fl <- rowSums(select(dat, one_of(items)) == 3)

# Miss error FV
dat$fag900fv <- apply(dat, 1, function(x) {

    # missing if no items were marked
    if (is.na(x["fag9anz1"]) | x["fag9anz1"] == 0 |
        is.na(x["fag9anz2"]) | x["fag9anz2"] == 0) return(NA)

    # responses of case
    d <- x[items]

    # responses to target stimuli on page 1
    d1 <- d[seq_len(x[["fag9anz1"]])]
    d1 <- d1[types[seq_len(x[["fag9anz1"]])] %in% c(1, 4)]
    # responses to target stimuli on page 2
    d2 <- d[seq_len(x[["fag9anz2"]]) + 320]
    d2 <- d2[types[seq_len(x[["fag9anz2"]]) + 320] %in% c(1, 4)]

    # sum of missed marks for target stimuli
    sum(c(d1 == 1, d2 == 1))
})


# False alarms FA
dat$fag900fa <- apply(dat, 1, function(x) {

    # missing if no items were marked
    if (is.na(x["fag9anz1"]) | x["fag9anz1"] == 0 |
        is.na(x["fag9anz2"]) | x["fag9anz2"] == 0) return(NA)

    # responses of case
    d <- x[items]

    # responses to distractors on page 1
    d1 <- d[seq_len(x[["fag9anz1"]])]
    d1 <- d1[types[seq_len(x[["fag9anz1"]])] %in% c(2, 3)]
    # responses to distractors on page 2
    d2 <- d[seq_len(x[["fag9anz2"]]) + 320]
    d2 <- d2[types[seq_len(x[["fag9anz2"]]) + 320] %in% c(2, 3)]

    # sum of marked distractors
    sum(c(d1 == 2, d2 == 2))
})
```

```
# Supplement errors FZ
dat$fag900fz <- apply(dat, 1, function(x) {

    # missing if no items were marked
    if (is.na(x["fag9anz1"]) | x["fag9anz1"] == 0 |
        is.na(x["fag9anz2"]) | x["fag9anz2"] == 0) return(NA)

    # responses of case
    d <- x[items]

    # responses and item types on page 1
    d1 <- d[seq_len(x[["fag9anz1"]])]
    types1 <- types[seq_len(x[["fag9anz1"]])]
    # responses and item types on page 2
    d2 <- d[seq_len(x[["fag9anz2"]]) + 320]
    types2 <- types[seq_len(x[["fag9anz2"]]) + 320]

    # errors on page 1
    e1 <- rep(NA, length(d1))
    e1[d1 == 3] <- "c" # line error
    e1[types1 %in% c(1, 4) & d1 == 1] <- "a" # miss error
    e1[types1 %in% c(2, 3) & d1 == 2] <- "b" # false alarms
    e1 <- e1[!is.na(e1)]
    # errors on page 2
    e2 <- rep(NA, length(d2))
    e2[d2 == 3] <- "c" # line error
    e2[types2 %in% c(1, 4) & d2 == 1] <- "a" # miss error
    e2[types2 %in% c(2, 3) & d2 == 2] <- "b" # false alarms
    e2 <- e2[!is.na(e2)]

    # supplement errors on page 1
    fz1 <- 0
    se1 <- gregexpr("(aaaaa+)|(bbbbb+)|(ccccc+)",
                    paste0(e1, collapse = ""))
    if (lapply(se1, function(x) length(x[x > 0])) > 0) {
        fz1 <- sum(attr(se1[[1]], "match.length"))
    }
    # supplement errors on page 2
    fz2 <- 0
    se2 <- gregexpr("(aaaaa+)|(bbbbb+)|(ccccc+)",
                    paste0(e2, collapse = ""))
    if (lapply(se2, function(x) length(x[x > 0])) > 0) {
        fz2 <- sum(attr(se2[[1]], "match.length"))
    }

    # sum of supplement errors
    fz1 + fz2
})
```

```
#
# Attention scores
#


# Number of marked items G
dat$fag9000g <- dat$fag9anz1 + dat$fag9anz2

# Marker value M = (G - FL) / G
dat$fag9000m <- (dat$fag9000g - dat$fag900fl) / dat$fag9000g

# Achievement value L = (G - FL) – 2 * (Fv + FA)
dat$fag9000l <- dat$fag9000g - dat$fag900fl - 2 *
                    (dat$fag900fv + dat$fag900fa)

# Quality value Q = L / G
dat$fag9000q <- dat$fag9000l / dat$fag9000g


# Continuity value K = Q * L
dat$fag9000k <- dat$fag9000q * dat$fag9000l

# Adjusted achievement score Ls = (G - FL) – 2 * (Fv + FA + FZ)
dat$fag900ls <- dat$fag9000g - dat$fag900fl - 2 *
                    (dat$fag900fv + dat$fag900fa + dat$fag900fz)

# Adjusted quality value Qs = Ls / G
dat$fag900qs <- dat$fag900ls / dat$fag9000g

# Adjusted continuity value Ks = Qs * Ls
dat$fag900ks <- dat$fag900qs * dat$fag900ls
```