Effectiveness of reasonable accommodations in students with ADHD: an experimental and intervention study[1]

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Abstract

Students with ADHD are more likely to underperform and drop out of higher education. Reasonable accommodations are used to help them deal with this challenge. However, the evidence base for the effectiveness of reasonable accommodations is limited, even for the popular extended examination duration. Therefore, we examined the effect of a test-taking strategy training during extended examination duration. Compared to the standard time condition, the trained group (*n*=23) improved its time-using strategies more than the untrained group (*n*=23) and consequently performed slightly better on a simulation exam. Next, effectiveness of separate room test-taking was investigated. Performance on a simulation exam did not differ in a whole group versus a separate room test-taking condition for students with and without ADHD (twice *n*=15). Combined, these results tentatively indicate that the effectiveness of frequently used accommodations is limited but potentially can be increased if they are part of a more comprehensive support plan.

Keywords: reasonable accommodations, ADHD, study strategies training, test-taking

1 Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by a stable pattern of impairing symptoms of inattention, hyperactivity and impulsivity which become evident across settings (American Psychiatric Association, 2013). Approximately two to eight percent of all students in higher education are diagnosed with ADHD (DuPaul, Weyandt, O'Dell, & Varejao, 2009). Their higher education trajectory is however complex: on average their test result is 11.05 percent lower than their peers without functional disability (Mortier, Demyttenaere, Nock, Green, Kessler, & Bruffaerts, 2015) and they are more likely to repeat grades and to drop out of higher education (DuPaul et al., 2009) as a result of their attentional, executive functioning, study skills and social problems (for review on specific educational needs in higher education students with ADHD: Emmers, Jansen, Petry, van der Oord, & Baeyens, 2016).

In order to cope with these problems, students with ADHD are in need of reasonable accommodations in higher education to which they are entitled since the ratification of the United Nations Convention on the Rights of Persons with Disabilities (2006). Reasonable accommodations are expected to neutralize the negative effect of the environment on the study and learning process of students with functional disability. In line with the Handicap Creation theory by Fougeyrollas (1995), problems (or handicaps) arise when there is a mismatch between characteristics of the individual (e.g., high distractibility in students with ADHD) and characteristics of the environment (e.g., excessive background noise when taking exams in large auditoria). By neutralizing the negative environmental effects (e.g., taking exams in a more quiet, separate room), reasonable accommodations will allow students with a disability to live up to their academic potential. By definition, implementing a reasonable accommodation would thus not lead to a better performance in students without a functional disability since there is no mismatch between personal and environmental characteristics and, as such, nothing to neutralize in this group. This theoretical assumption is referred to as the interaction hypothesis (Sireci, Scarpati, & Li, 2005).

However, previous studies in secondary school samples reveal that children without functional disability too show an increased performance when extended exam duration is offered, albeit less pronounced than their peers with a learning disability (e.g., Meloy, Deville, & Frisbie, 2002; Schulte, Elliot, & Kratochwill, 2001). This observation is called the differential boost hypothesis (Sireci et al., 2005) and questions the fairness of reasonable accommodations since these accommodations seem to do more than neutralizing environmental characteristics in students with a functional disability. Determining both the effectiveness and the fairness of a particular reasonable accommodation, would require a full factorial research design (i.e. students with vs without functional disability in exam conditions with vs without the reasonable accommodation). This practically rules out studying this phenomenon in naturalistic exam situations (since we cannot ask students to take exams twice) and paves the way for testing during simulation exams. In the case of ADHD, only a handful of studies have investigated the effectiveness and fairness of reasonable accommodations in (higher) education in such a way.

Extended examination duration is the most used reasonable accommodation for students with ADHD in (higher) education. Students with ADHD also (subjectively) perceive this accommodation to be effective to deal with their attention problems (Jansen, Petry, Ceulemans, van der Oord, Noens, & Baeyens, 2017). The majority of studies examining the objective effectiveness of extended examination duration in terms of increased test scores and across age groups, however, classifies this reasonable accommodation as unfair and/or ineffective (e.g., Jansen, Petry, Evans, Noens, & Baeyens, 2018; Miller, Lewandowski, & Antshel, 2015; Pariseau, Pelham, Fabiano, Massetti, & Hart, 2010). A recent review by Lovett and Nelson (2020) indicated that, based on two experiments, read-aloud accommodations (i.e., orally presenting items from a paper test to students) improve performance in students with ADHD beyond any benefit seen in their peers without a functional disability. This effect is probably due to the increased focus of attention in the one-on-one situation with the examiner. Other reasonable accommodations remain underinvestigated. In his editorial, Arnold (2020) refers to “an inconvenient finding … in light of the widespread recommendations for and use of school accommodations for ADHD”.

Before advising against the use of reasonable accommodations, research should however take a closer look at the current situation. First, in their review, Harrison and colleagues (2013) differentiate between four categories of reasonable accommodations: presentation accommodations (e.g., read-aloud accommodations), response accommodations (e.g., using speech-to-text software), timing/scheduling accommodations (e.g., extended examination duration) and setting accommodations (e.g., separate room test-taking). Up until now, some categories have hardly been tested on the effectiveness of their specific accommodations. For instance, students with ADHD in higher education subjectively report in surveys that separate room test-taking is effective to deal with their difficulty sitting still, completing tasks, and sustaining attention (Jansen et al., 2017) but so far objective measures in an experimental design have not been used. Second, an extended examination duration experiment by Jansen and colleagues (2018) revealed that participants in higher education were not using test-taking strategies that were considered to be effective when taking the (simulation) exam (e.g., marking key words during a comprehensive reading subtest). Even more, although participants in both the control and ADHD group worked slower in the extended time condition than in the standard time condition, they did not alter any other test-taking strategy when more time was available. Test-taking strategies refer to the cognitive skills that allow a person to handle a test situation adequately in order to maximize the test score “to the limit allowed by the level of their knowledge and preparation for the test” (Dodeen, 2015, p.108). Millman, Bishop and Ebel (1965) developed a seminal test-taking taxonomy which separates test-taking skills into two categories: skills that are independent of the test purpose or constructor, and skills that are dependent of the test purpose or constructor. The former category refers to time-using strategies (e.g., first focusing on exam questions that you know how to answer), error-avoidance strategies (e.g., going through all multiple-choice options first before answering), guessing strategies (e.g., only make guesses when there is no correction for guessing in a multiple-choice exam) and deductive reasoning strategies (e.g., immediately eliminating answers in a multiple-choice exam of which you are sure they are incorrect). The latter category includes intent consideration strategies (e.g., determining the purpose of the questions before formulating your answers) and cue-using strategies (e.g., using reference words to formulate your answer). Studies in (primarily) primary and secondary students, indicate that test-taking strategy trainings lead to higher test scores (Dodeen, 2015; Hong, Sas & Sas, 2006; Cohen's d=0.33 in a meta-analysis of Samson (1985)) as well as a reduction in stress and an increase in self-confidence to take exams (Al Fraidan & Al-Khalaf, 2012). Students with ADHD in secondary education have been reported to struggle with time-using strategies (Daley & Birchwood, 2010) and are more stressed during exams (Lewandowski, Gathje, Lovett, & Gordon, 2012). The use of other strategies has not explicitly been tested in students with ADHD or did not reveal a difference with control groups (Lewandowski et al., 2012). It remains to be seen whether training test-tasking strategies in students (particularly with ADHD) could increase the effectiveness of extended examination duration as this condition would allow students to optimally integrate these strategies to make most of the extra time that becomes available.

2 Current study

The current paper reports on an intervention study and an experimental study. Both studies measure test performance on a simulation exam, identical to the paper-and-pencil task described in Jansen et al. (2018).

In the intervention study, we build on the findings of Jansen et al. (2018) that test performance and test-taking strategy use of students with and without ADHD did not significantly differ between a standard and an extended time condition. In the current study we adopt a dimensional (non-categorical) approach to ADHD and set out to complement the study by Jansen and colleagues (2018) by training test-taking strategies of students (including time-using and stress-reduction strategies) before taking the simulation exam in an extended time condition and determine whether such a training could increase the objective effectiveness of extended examination. More specifically, we will investigate (1) whether test performance of students who took the test-taking strategy training will improve and benefit more from extended examination duration than students who did not take the training, and (2) whether the gain in strategy use and test performance after training is larger for students with more ADHD symptoms.

In the experimental study, we aim to mitigate the need for more evidence-based use of reasonable accommodations in education by -for the first time- investigating the effectiveness of separate room test-taking in higher education students with a (categorical) diagnosis of ADHD. More specifically, we set out to determine whether students with ADHD benefit more from separate room test-taking than students without ADHD on objective and subjective measures.

3 Intervention study

3.1 Methods

Participants

Participants were eligible for study entry when (1) they were between 18 and 25 years old; (2) they were enrolled in an institution of higher education; (3) they reported no (known) sensory or motor disability that would interfere with taking part in the study (since the simulation exam did not allow for other reasonable accommodations to be offered to participants than the one under investigation). Students were recruited by posting ads in Facebook groups from different educational programs and by hanging flyers in higher education buildings. Those interested contacted the researcher for more detailed information after which they could decide to complete the informed consent letter. In total 75 students showed interest in participation. Within this group we selected pairs of students that shared the same gender, age, program (being enrolled in either a professional or academic program), and education group (being enrolled in a program from Humanities and Social Sciences; Science, Engineering and Technology; or Biomedical Sciences). Twenty-three matched pairs could be selected from which one pair member was randomly assigned to the experimental condition (i.e. the test-taking strategy training) and the other member to the control condition (i.e. no training). In the experimental group one student had a (mild) reading disability (which did not require reasonable accommodations during exams) while no students were diagnosed with a neurodevelopmental disorder (e.g., ADHD); in the control group none of the students had a learning or neurodevelopmental disorder. Table 1 shows that both groups did not significantly differ in terms of self-report on ADHD symptomatology and study strategy use. In both groups, the inattention scores of participants ranged from normal to clinical range, while for hyperactivity/impulsivity the scores ranged from normal to subclinical.

Procedures

All procedures were approved by the Social and Societal Ethics Committee of the University of Leuven (G-2019-01-1500). After completing the informed consent, all participants filled in the ADHD Rating Scale (ARS) and the Learning and Study Strategies Inventory (LASSI).

During the experiment, participants had to complete two parallel versions of a paper-and-pencil test that has been previously used as a simulation exam in Jansen et al. (2018). The two parallel versions were counterbalanced over the two time conditions of the experiment. The first time the test was taken in the standard time (ST) condition of 1 hour, and 1 week later for a second time in the extended time (ET) condition of 1 hour + 33% (i.e. 1h 20 minutes). The standard time condition duration was set at 1 hour as this was the average time to take the test plus 1 standard deviation in typically developing controls.

In between both tests, students of the experimental condition followed a test-taking strategy training. After taking the second test, participants also completed an adaptation of the Study Strategy and Experiences Questionnaire developed by Jansen and colleagues (2018). t

In order to increase the ecological validity of the simulation exam, all procedures of a real-life exam were copied (e.g., waiting in the hall before the exam, being quiet upon entering the examination room, leaving all personal belongings in front of the examination room). Also, an actor was added to the participants to monitor the noise levels in the examination room. The actor was instructed to follow a guideline which was based on observations of a naturalistic examination situation. This guideline contained manipulations the actor had to undertake at a predetermined time if noise levels would be too low, for example dropping a pencil or asking a question. Finally, in order to make this simulation a high stakes situation, the top 25 percent performers on the simulation exam received a fifteen euro bonus on top of the ten euro reward for all participants.

Three participants (of which one in the experimental group) took attention-enhancing medication on a daily basis. They were instructed to keep their medication stable during the whole study or, if otherwise indicated by their general practitioner, inform us of any medication or dose changes. No such changes were reported.

Instruments

After enrolling in the study, participants completed the ADHD Rating Scale (ARS; Kooij, Buitelaar, van der Oord, Furer, Rijnders, & Hodiamont, 2005; for continuous norms in a Flemish sample: Baeyens, Van Dyck,

Table 1

Demographic characteristics, ADHD symptomatology and study strategy use of the participating students in the experimental and control group

		Control group (n = 23) n (%)	Experimental group (n = 23) n (%)	
Sex (males, %)		**10 (43.47)**	**10 (43.47)**	
Mean age (*SD*)		21.26 (1.45)	21.26 (1.45)	
Type of educational program	Professional	7 (30.43)	7 (30.43)	
	Master	16 (69.57)	16 (69.57)	
Group (%)	Humanities and social sciences	17 (73.91)	17 (73.91)	
	Science, engineering, and technology	3 (13.04)	13 (13.04)	
	Biomedical science	3 (13.04)	3 (13.04)	
		Control group (n **= 23)** M (SD)	**Experimental group** (n **= 23)** M (SD)	**Test statistic** t **(**df**=44)**
ADHD Rating Scale (ARS)				
Inattention		8.78 (4.18)	6.91 (3.30)	1.68
Hyperactivity/Impulsivity		9.26 (4.15)	8.13 (5.49)	0.79
Learning and Study Strategies Inventory (LASSI)				
Attitude		31.22 (5.08)	32.26 (3.60)	-0.80
Motivation		26.87 (3.96)	28.26 (3.63)	-1.24
Time Management		25.70 (6.41)	25.43 (4.55)	0.16
Anxiety		27.30 (7.35)	25.78 (5.81)	0.78
Concentration		25.35 (4.93)	27.22 (5.09)	-1.27
Information processing		28.26 (3.97)	28.00 (4.08)	0.22
Selecting main ideas		20.00 (3.69)	18.43 (2.35)	1.72
Study Aids		25.04 (5.55)	25.52 (4.71)	-0.32
Self-testing		23.30 (4.92)	22.61 (3.12)	0.57
Test strategies		31.52 (4.01)	30.74 (4.68)	0.61

Note. n/a = not applicable since participants were matched pairwise

Broothaerts, Danckaerts & Kooij, 2011). For this study, only the 25 items mapping the current symptoms of inattention and hyperactivity/impulsivity were administered. Twelve of these items questioned problems related to inattention, while thirteen were related to hyperactivity/impulsivity. All items were answered on a four point likert scale. At the same time, participants also filled in the Learning and Study Strategies Inventory (LASSI; Lacante & Lens, 1999; in Lacante et al., 2001). Here, participants completed 77 items on a five-point Likert scale measuring a self-regulation component (subscales concentration, self-testing, test-strategies and time-management), an affect and motivation component (subscales anxiety, attitude and motivation) and a skill-specific component (information processing, selecting main ideas and study aids).

During the experiment, a paper-and-pencil test developed by Jansen et al. (2018) was used. The tests comprised of three subtests, namely arithmetic, matrix reasoning and comprehensive reading. First, the subtest arithmetic was inspired by the Wechsler's Intelligence Scale (WAIS-III; Wechsler, 1997) and consisted of 12 arithmetic questions. Students had to solve each problem by giving a short answer. Writing any intermediate results was not tolerated. The maximum score of this subtest was 12. The second subtest, Matrix reasoning, was also inspired by the WAIS-III and contained 9 items. Students were given 4 possibilities and they were asked to select the correct answer. The maximum score of this subtest was 9. Third, the comprehensive reading subtest was based on the Davis Reading Test (DRT; Davis & Davis, 1962). In total, the comprehensive reading component consisted of 14 multiple choice questions divided over 3 to 5 reading texts (depending on the parallel version). For each question, five possible answers were given to the students and they were asked to indicate the correct answer. The maximum score of this subtest was 14. In the end, a total score of each participant was calculated by adding the points for each subtest (maximum score of 35). Finally at the end of the experiment, participants completed a Study Strategies and Experiences Questionnaire developed by Jansen et al. (2018). Extra items were added to the original questionnaires to measure all components of the test-wiseness taxonomy of Millman and colleagues (1965). The study strategy part of the questionnaire is reported here and consisted of 18 items rated on a five-point Likert scale and measures the participants' strategy use during test-taking. The questionnaire was completed at the end of the second test. Here, they reported on both conditions.

Intervention

The test-taking strategy training for the participants in the experimental condition was developed for the current study. The test-wiseness taxonomy of Millman and colleagues (1965), complemented with a module on stress-reduction strategies, provided the theoretical framework of the training. Goals of the training were learning to: 1) divide time over exam sections; 2) deduct the purpose of a test and the expectations of the test constructor; 3) implement strategies to eliminate answers and avoid making mistakes during open-ended and multiple-choice exams; 4) recognize key words and misleading information in exam questions; 5) use breath relaxation techniques to handle stress. The specific content was provided by analyzing and integrating existing study strategy trainings developed by student support offices of several Flemish and Dutch universities and university colleges.

The methodology of the training was based on the First Principles of Instruction model by Merrill (2002). A guiding principle in this model is that the attention span of students is 20 minutes. As such, the training should use (short) combinations of formal instruction and activity sessions. For this training the methods used were activating prior knowledge (*activation)*, providing new information on strategies followed by exercises/polling/group debate on the topic (5 modules; *demonstration and application*), personal reflection and writing a flash card (*integration*). The training took 80 minutes, including a 10 minutes break.

Statistical analysis
For the intervention study, 2 groups (experimental, control) x 2 time (ST, ET) repeated measures analyses of variance were used to analyze the (differential) impact of the test-taking strategy training on strategy use and test performance (hypotheses 1 and 2). Since participants were pair-wised matched for gender, age, program and education group and no group-differences were found on the ARS and LASSI (see Table 1), no covariates were added to the analyses. Pearson correlations were used to analyze the association between strategy use/test performance gain (i.e. difference score between scores on both time conditions) and ARS inattention and hyperactivity/ impulsivity scores (hypothesis 3). All analyses were repeated without the pair that contained the student with a learning disability; as the pattern of findings did not change by in- or excluding this pair, only the analyses on data of all pairs will be reported.

3.2 Results
Hypothesis 1: do students who took the test-taking strategy training (=experimental condition) use more strategies when retaking the exam compared to students who did not take the training (=control condition)?

As displayed in Table 2, all strategies measured with the Study Strategies and Experiences Questionnaire significantly improved between the two measurements ($F(1,44)$-values main effect of time > 5.82, p-values < 0.02, η^2 > 0.117). For the Error-avoidance and Time-using strategies the average use was higher in the experimental group than in the control group ($F(1,44)$-values main effect of time > 4.47, p-values < 0.04, η^2 > 0.092). A significant Time x Group effect was only found for the Time-using strategy ($F(1,44)=9.10$, $p=0.004$, $\eta^2=0.171$) indicating that the experimental group used this strategy more over time (Standard Time of 1h (ST): $M(SD)=1.38$ (0.81), Extended Time of 1h + 1/3 (ET): $M(SD)=2.15$ (0.91)) than the control group (ST: $M(SD)=1.13$ (0.75), ET: $M(SD)=1.32$ (0.88)).

Hypothesis 2: does the test performance of students who took the test-taking strategy training (=experimental condition) improve more from extended examination duration than students who did not take the training (=control condition)?

In the ST condition, the number of exam items answered correctly on the total score or any of the subtests did not significantly differ between the control and the experimental group (all $F(1,44)$-values < 0.273, p-values > 0.598). When comparing the ST condition to the ET condition, a main effect of Time was found on the total score ($F(1,44)=19.33$, $p<0.001$, $\eta^2=0.305$) as well as a Time x Group interaction effect ($F(1,44)=7.34$, $p=0.010$, $\eta^2=0.143$) indicating that students in the experimental group (ST: $M(SD)=20.26$ (5.22), ET: $M(SD)=23.74(5.42)$) improved their total score significantly more than the students in the control group (ST: $M(SD)=20.39$ (3.76), ET: $M(SD)=21.22(5.17)$) when extra examination time was offered. On the Comprehensive reading subscale, the main effect of Time only showed a trend towards significance ($F(1,44)=3.44$, $p=0.071$, $\eta^2=0.0.72$) whereas the Time x Group interaction effect reached significance ($F(1,44)=6.87$, $p=0.012$, $\eta^2=0.135$). Here too, the number of items answered correctly increased significantly more in the experimental group (ST: $M(SD)=8.96$ (2.65), ET: $M(SD)=10.48(2.02)$) compared to the control group (ST: $M(SD)=9.35$ (2.33), ET: $M(SD)=9.09$ (2.28)) when extra exam time was offered. On the Arithmetic and Matrix reasoning subtests only a main effect of Time was found (resp. $F(1,44)=6.46$, $p=0.015$, $\eta^2=0.128$ and $F(1,44)=5.59$, $p=0.023$, $\eta^2=0.113$) indicating an overall better performance at second measurement. See Table 2 for more detailed results.

Hypothesis 3: is the gain in strategy use and performance after training larger for students with more ADHD symptoms?

In the experimental group, 21 students had a higher raw total performance score in ET compared to ST while 1 student had an equal score and 1 student a lower score. Total

Table 2

Strategy use measured by the Study Strategies and Experiences Questionnaire and performance on the simulation exam of the control (n=23) and the experimental group (n=23) during standard and extended time

	Control group		Experimental group				
	ST *M* (*SD*)	**ET** *M* (*SD*)	**ST** *M* (*SD*)	**ET** *M* (*SD*)	**Time** *F(1,44)*	**Group** *F(1,44)*	**Time x Group** *F(1,44)*
Strategy use							
Error-avoidance	1.21 (*0.64*)	1.75 (*0.58*)	1.57 (*0.83*)	2.19 (*0.78*)	25.22***	5.09*	0.07
Time-using	1.31 (*0.75*)	1.32 (*0.88*)	1.38 (*0.81*)	2.15 (*0.91*)	9.63**	4.47*	9.10**
Guessing	1.85 (*0.83*)	2.06 (*0.81*)	1.47 *(0.96*)	1.87 (*0.62*)	7.63**	1.79	0.80
Deductive reasoning	2.64 (*1.09*)	3.00 (*1.14*)	2.78 (*0.54*)	3.065 (*0.65*)	6.63*	0.19	0.90
Cue-using and intent consideration	0.46 (*0.64*)	0.76 (*0.77*)	0.80 (*0.79*)	1.11 (*0.81*)	5.82*	3.59	0.00
Stress-reduction (breath relaxation)	1.21 (0.66)	1.48 (0.49)	1.55 (0.78)	1.60 (0.44)	5.94*	2.41	1.67
Performance							
Total scale	20.39 (3.76)	21.22 (5.17)	20.26 (5.22)	23.74 (5.42)	19.33***	0.76	7.34**
Subscale Arithmetic	5.22 (2.54)	5.83 (3.00)	5.32 (2.68)	6.74 (3.33)	6.46*	0.61	0.72
Subscale Matrix Reasoning	5.83 (1.47)	6.30 (1.58)	5.78 (1.24)	6.52 (1.34)	5.59*	0.07	0.26
Subscale Comprehensive Reading	9.35 (2.33)	9.09 (2.28)	8.96 (2.65)	10.48 (2.02)	3.44	0.70	6.87*

*Note * p < .05, ** p < .01, *** p < .001*

SD = standard time (1h), ET = extended time (1h + 1/3)

strategy use increased from ST to ET in 20 students and was reduced in 3 students. As such, we calculated the variables "gain in performance/strategy use after training" by distracting the ST scores from the ET scores.

Pearson correlations in the experimental group revealed a trend towards significance between the self-report ratings of ARS Inattention and gain in Time-using strategy (r=-0.411, p=0.052). None of the other correlations between ARS subscales and gain in strategy use revealed (a trend towards) significance (all r-values < -0.350, p-values > 0.101). Similarly, no significant correlations were found between ARS subscales and gain in performance on total or subscale scores (all r-values < -0.263, p-values > 0.225).

3.3 Discussion

In their experiment on the effectiveness of extended examination duration, Jansen and colleagues (2018) did not find improved test scores on a simulation exam for both controls with and without ADHD in the extended time condition. The authors did however report that test-taking strategies were hardly used and did not change across time conditions. Given that better strategy use is associated with higher test scores (Dodeen, 2015), we set out to determine whether a training in test-taking strategies could improve the objective effectiveness of extended examination duration.

Our analyses to test hypothesis 1 indicate that irrespective of (not) taking part in the training, all strategies were used significantly more at the time of the second testing. This increase could be considered as a learning effect: participants learned over time which strategies are best to be used when taking a parallel test for the second time. A corresponding significant main effect of Time was found for test performance on the total score as well as subtest scores of the Arithmetic and Matrix reasoning subtests (and a trend towards significance for Comprehensive reading).

A training effect becomes evident in the significant interaction effect for time-using strategies: after taking the training the use of time-using strategies increased significantly more in the experimental group compared to the control group. Conversely and in line with literature (Dodeen, 2015), we found a significant Time x Group interaction effect on the total test score and on the Comprehensive reading subtest testscore. Improving test-using strategies after a training indeed is most likely to have a positive impact on the final subtest in a simulation exam as participants learned to better divide time over all sections of the test. On a more critical note, the current Arithmetic and Matrix reasoning subtests are in their development inspired by an intelligence test; as proxies of the (more or less stable) intelligence construct room for improvement on these subtest may be quite limited whereas comprehensive reasoning may be more prone to change.

Importantly, this finding shows tentative evidence that effectiveness of extended examination duration can be established provided that this reasonable accommodation is part of a more comprehensive support plan (i.e. including a training on which strategies to use during (extended) exam taking). As was the case in the original study by Jansen et al. (2018), participants took significantly more time to take the test in the extended time condition ($p < 0.05$). Future studies need to determine whether the training effect could also be replicated in a standard time condition, making extended time redundant.

Also, it is important to consider which student characteristics are associated with the training effect of time-using strategies on test performance. Pearson correlations did not reveal a significant correlation between gain in test performance/strategy use and presence of ADHD symptomatology, which is in line with literature (Lewandowksi et al., 2012) but indicates that the positive effect of a test-taking strategy training on extended examination duration is a generic rather than an ADHD-specific effect. As such and in terms of the Handicap Creation theory, it is questionable that the mismatch between characteristics of the individual and of the environment, will be fully resolved with the current training focus. Positive effects of test-taking strategies, not tested in the context of reasonable accommodations, have primarily been found in younger, less-experienced age groups (Flippo & Caverly, 2009). Given the learning effect in this test, we could expect that first year bachelor students would benefit more from such a training in the context of reasonable accommodations than the already more experienced, primarily Master students that took part in this study.

A major limitation of this intervention study is the small sample size, leaving small or moderate training effects undetected. Also, in this study we adopted a dimensional approach for ADHD since we primarily wanted to test whether a test-taking strategy training could improve performance in extended examination time conditions. Although correlation analysis already revealed that training effects seem to be ADHD-a-specific, we acknowledge that ADHD is more than just the presence of symptoms of inattention, hyperactivity and/also impulsivity. With the current approach we did not take into account the age-of-onset, impairment, and pervasiveness criteria of an ADHD classification nor the special educational needs, hereby potentially minimizing the range of impairing symptoms and excluding extreme scores and actual needs in our sample. Our current correlational analysis assumes linearity in the association, however clinical cases of ADHD might not follow this trend and, as such, (other) training effects might be masked.

Another limitation in this study is that we relied on delayed self-report to determine the use of study strategies. In our efforts to avoid a test-effect in the control group, participants completed the Study Strategies and Experiences Questionnaire only after the second test-taking asking them to reflect on strategy use during both the first test-taking (i.e., one week before) as well as on the current, second test-taking (i.e., during the second test session, one week after the first test session), which could have affected the accuracy of the measures for the standard time condition and, as such, the reported evolution over time. Finally, despite our efforts to resemble this simulation exam to a naturalistic situation, reported stress levels remained low ($M(SD)$=3.01(0.89) on a five-point Likert scale), hereby leaving not much room for intervention effects in the stress-reduction strategies (Lewandowski et al., 2012).

4 Experimental study

4.1 Methods

Participants
Participants were eligible for study entry in the ADHD group when (1) they were between 18 and 25 years old; (2) they were enrolled in an institution of higher education; (3) they previously received an ADHD diagnosis by a psychiatrist or a multidisciplinary team including a psychiatrist, and this diagnosis was validated in this study by using the ARS (Kooij et al., 2005; for continuous norms in a Flemish sample: Baeyens, Van Dyck, Broothaerts, Danckaerts & Kooij, 2011) and the Diagnostic Interview for ADHD in Adults (Kooij & Francken, 2010) (i.e. a categorical approach to ADHD); and (4) they reported no (known) sensory or motor disability that would interfere with taking part in the study. Students with ADHD were recruited in different institutions of higher education in Flanders through the student counsellors in these institutions.

Participants were included in the control group when (1) they were between 18 and 25 years old; (2) they were enrolled in an institution of higher education; (3) they reported no known disabilities; and (4) no (sub)clinical scores of ADHD symptomatology were found on the ARS. These students were recruited by posting ads in Facebook groups from different educational programs and by hanging flyers in higher education buildings.

For both the ADHD and control group, interested students contacted the researcher for more detailed information after which they could decide to complete the informed consent letter. In total 84 students showed interest in participation of which fifteen met the criteria for the ADHD group. Each student with ADHD was pairwise matched in terms of gender (eleven females, four males), age ($M(SD)$=21.58(3.02), program (eleven students in a professional program and four in an academic program), and education group (eleven students in Humanities and Social Sciences, four students in Science, Engineering and Technology or Biomedical Sciences). Students in the ADHD group scored significantly higher on the ARS subscale Inattention (ADHD: $M(SD)$=22.13(2.56), control: $M(SD)$=7.53(4.84); $F(1,29)$=118.67, p<.001) and the ARS subscale Hyperactivity/ Impulsivity (ADHD: $M(SD)$=5.47(5.51), control: $M(SD)$=1.60(2.44); $F(1,29)$=6.16, p=.019). Three students in the ADHD group had a comorbid condition (i.e. two students had a learning disability, one student had an anxiety disorder). Fourteen students in the ADHD group used psychostimulants on a daily basis, including during this experiment. None of the students in both groups participated in the intervention study (and vice versa). Psychostimulant use was allowed for this study (and for previous studies on effectiveness of reasonable accommodations in students with ADHD) since the purpose of this field of research is to test whether we adequately accommodate the "average" student with ADHD (i.e., taking psychostimulants, particularly in young adulthood and during exam periods) in our education system. As such, this choice contributes to the ecological validity of this research.

The remaining 54 students participated either in the role of an actor (cfr. supra) or in the role of a (mock) student taking the test (as we needed large student numbers to create a whole group and a separate room test-taking condition; cfr. infra).

Procedures
All procedures were approved by the Social and Societal Ethics Committee of [*University of Leuven*] (G-2019-01-1501). After completing the informed consent, all participants completed the ADHD Rating Questionnaire (ARS) to check the in-/ exclusion criteria of both groups. Additionally, we also administered the Diagnostic Interview for ADHD in adults (Kooij & Francken, 2005) from participants in the ADHD group.

Each participant took two parallel versions of the paper-and-pencil test that was also used in the intervention study. The two parallel versions were counterbalanced over the two conditions of the experiment: the whole group test-taking condition and the separate room test-taking condition. In the whole group condition, participants took the paper-and-pencil task in the presence of at least 30 other students. In the separate room condition, the presence of other students was restricted to only two to five additional students in the room (as is the case in naturalistic separate room test-taking). Half of the participants started in the whole group condition and, after a half an hour break, took the parallel test in the separate room condition. The other half of the participants took the conditions in the opposite order. The same procedures were followed as in the intervention study to guarantee ecological validity of the simulation exam.

After taking the second test, participants also completed an adaptation of the Study Strategy and Experience Questionnaire (SSEQ) developed by Jansen and colleagues (2018).

Instruments

For a description of the ADHD Rating Scale en the paper-and-pencil task, we refer to the Instruments section of the intervention study.

The Diagnostic Interview for ADHD in Adults (Kooij & Francken, 2005) was used to determine whether the ADHD classification is still valid at the time of the experiment. ADHD symptomatology fluctuates over time in that hyperactivity/impulsivity often decreases in adolescence, while inattention symptoms remain more stable and emotion dysregulation often only first emerges in adolescence and young adulthood (Emmers et al., 2016). As a result, childhood ADHD diagnoses sometimes cannot be confirmed at a later age. The Diagnostic Interview for ADHD in Adults is a structured interview which is used to determine whether ADHD symptoms are currently present and have been present during childhood.

Finally, participants completed an adaptation of the Study Strategies and Experience Questionnaire developed by Jansen et al. (2018) at the end of the experiment. In this experiment we only report on the part that measures test experiences using fifteen items rated on a five-point Likert scale. Items assessing the motivation, concentration, calmness, and visual and auditory distraction in each condition were completed for each condition separately; two items were only completed once: an item testing the similarity of the simulation exam to a real life exam, and an item directly assessing whether the student felt that exam taking in the separate room condition was more effective than in the whole group condition.

Statistical analysis

A two groups (ADHD, control) x two conditions (whole group, separate room) repeated measures analyses of variance were used to determine the (differential) impact on test performance (hypothesis 1) and test experience (hypothesis 2). Items on the Study Strategies and Experience Questionnaire that were tested irrespective of condition, were analyzed using univariate analysis of variance. Since participants were pair-wised matched for gender, age, program and education group, no covariates were added to the analyses. All analyses were repeated without the pair that contained the three students with a comorbid condition; as the pattern of findings did not change by in- or excluding this pair, only the analyses on data of all pairs will be reported.

4.2 Results

Hypothesis 1: Do students with ADHD benefit more from separate-room test-taking than students without ADHD on objective test performance measures?

As displayed in Table 3, mean scores in the whole group condition were higher than in the separate room condition for both groups. However, test performance on the total test and the subtests did not significantly differ between the two test-taking conditions (all $F(1,28)$-values < 1.94, p-values > 0.18), nor was there a significant time x group

Table 3
Test performance and test experience of students with (n=15) and without (n=15) ADHD during whole group vs. separate room test-taking

	Control group		ADHD group				
	WG ***M* (*SD*)**	**SR** ***M* (*SD*)**	**WG** ***M* (*SD*)**	**SR** ***M* (*SD*)**	**Condi-tion** ***F(1,44)***	**Group** ***F(1,44)***	**Condition x Group** ***F(1,44)***
Performance							
Total scale	21.20 (4.86)	20.73 (5.42)	24.53 (5.77)	23.53 (6.87)	1.26	2.34	0.17
Subscale Arithmetic	6.40 (3.05)	6.20 (2.06)	7.73 (3.54)	7.20 (3.65)	0.14	1.22	0.70
Subscale Matrix Reasoning	6.27 (0.96)	6.00 (1.51)	6.93 (1.22)	6.87 (1.41)	0.59	3.49[a]	0.18
Subscale Comprehensive Reading	9.13 (2.48)	8.27 (2.96)	10.20 (2.18)	9.60 (3.04)	1.94	2.10	0.06
Experience							
Concentration problems	2.13 (0.83)	2.33 (1.23)	3.13 (0.74)	2.87 (0.74)	0.02	9.93**	1.06
Visual distractors by others	1.33 (0.49)	2.07 (1.28)	2.53 (1.36)	2.07 (1.28)	1.32	4.29*	4.04[a]
Auditory distractors by others	2.07(1.10)	2.13 (0.74)	3.20 (1.15)	2.80 (1.52)	0.43	7.06*	0.84
Being calm	4.00 (0.85)	4.20 (0.94)	3.80 (1.01)	3.87 (0.74)	0.59	0.94	0.15
Being motivated	3.80 (0.68)	3.73 (0.96)	3.87 (0.83)	3.73 (0.88)	0.37	0.02	0.04

*Note [a] p<.10, * p < .05, ** p < .001*

WG = whole group test-taking, SR = separate room test-taking (i.e. 2 to 5 additional students in the exam room)

interaction effect (all F(1,28)-values < 0.70, p-values > 0.41). The latter analysis indicates that there is no difference in exam performance in the two test-taking conditions (i.e. separate room and whole group) between the ADHD and the control group.

On the subtest Matrix reasoning, there was a trend towards significance indicating that the performance of the ADHD-group was higher than of the control group (F(1,28)=3.49, p=0.07, η^2=0.11). No significant main group effects on other test scores were found (all F(1,28)-values < 2.34, p-values > 0.14)

Hypothesis 2: Do students with ADHD benefit more from separate-room test-taking than students without ADHD on subjective measures of test-taking?

On a five-point Likert scale (1 = totally disagree, 5 = totally agree), both the ADHD and control group rate the simulation exam as somewhat similar to a real-life exam (ADHD: *M(SD)*= 3.47(0.74), Control: *M(SD)*=3.80(1.01); univariate F(1,28)=1.05, p=0.31). The effectiveness of separate room test-taking on test performance was subjectively experienced as somewhat unfavorable in both groups (ADHD: *M(SD)*= 2.80(0.86), Control: *M(SD)*=2.73(1.10); univariate F(1,28)=0.03, p=0.86).

Table 3 shows that during the experiment students with ADHD are more visually and auditory distracted by others and experience more concentration problems than students without ADHD (all repeated measures F(1,28)-values > 4.29, p-values < 0.01, η^2 > 0.20). A trend towards significance for the condition x group interaction effect indicated that students with ADHD are visually more distracted by others in the whole group versus the separate room condition, whereas the opposite is the case in the control group (repeated measures F(1,28)=4.04, p=0.05, η^2=0.126). No significant main effects of condition nor condition x group interaction effects were found on other outcome variables (all repeated measures F(1,28)-values < 1.32, p-values > 0.26).

4.3 Discussion

In their systematic review, Lovett and colleagues (2020) pointed out that experimental research on the effectiveness of reasonable accommodations for students with ADHD, other than extended examination duration and read-aloud accommodations, is scarce. Given the large variety of (categories of) accommodations that remain untested, the current experiment aimed to shed a light on the effectiveness of separate room test-taking as a setting accommodation for students with ADHD in higher education.

Our experiment did not provide evidence for the interaction hypothesis nor for the differential boost hypothesis as no effect of whole group or separate group test-taking on objective test performance could be found. This finding was backed by the lack of subjective experience of effect of separate room test-taking in both the ADHD and the control group, despite previous self-report studies suggesting otherwise (Jansen et al., 2017). The absence of an effect is unlikely to be explained by a lack of ecological validity of the simulation exam as the similarity with naturalistic exams and an adequate level of motivation for test-taking was confirmed by participants. Also, students with ADHD experienced (more) visual distractors (than the control group) in the whole group condition compared to the separate room condition. The null findings could be explained by at least two other factors. First, the symptomatic heterogeneity of ADHD makes it unlikely that one and the same accommodation, in this case separate room test-taking, would always be able to neutralize the mismatch between personal and environmental characteristics. The effectiveness seems to be a function of symptoms, age, and teaching and evaluation methods (Jansen et al., 2017). Kettler (2012) therefore suggests that the selection and implementation of reasonable accommodations should be individually tailored in order to be effective. Due to practical barriers (e.g., accommodations often granted based on certification of a disorder rather than on current special educational needs, or time constraints to service all students before the start of exams) this is seldom the case in higher education and the effect of such individually tailored accommodations has not been experimentally tested (e.g., in single case design studies). Second, although we did not administer an intelligence test, we could detect a (near) significant group difference on Matrix reasoning (a subtest inspired by WAIS-III and a proxy of fluid intelligence): students with ADHD outperformed their peers without the disorder. This adds to the suggestion that students with ADHD in higher education have increased intellectual skills which help them overcome many of their disorder-specific problems such as attentional and executive functioning problems (Emmers et al., 2016), but could also narrow the room for improvement on this particular subtest.

Objective and subjective measures in this experiment, thus, do not indicate any added value of separate room test-taking for students with ADHD. We should however stress that this remains a simulation exam that did not require prior studying of specific material and which was taken by a rather small sample of students. Due to the wide variety of study programs of our participants, we opted for a test measuring generic skills. It is however likely that students with ADHD are already hampered by their problems during learning in the classroom and at home, come less prepared to a (real-life) exam than their peers and therefore underperform. This was not the case in the current simulation exam, limiting the chances to detect underperformance and remediation in a reasonable accommodation condition. Also, with sample sizes of fifteen participants per group the power of the statistical analyses is low and leaves small or even moderate analyses undetectable. Nevertheless, although not reaching significance, it remains noteworthy that average test scores were lower in the separate room condition than in the whole group condition, despite the latter condition leading to more distraction and concentration problems. ADHD has a multifactorial etiology and in some cases symptomatology can be explained by underarousal in specific brain regions. There is evidence that white noise (i.e., meaningless, monotonous noise) can optimize arousal and activation processes in the brain hereby leading to better performances (Baijot et al., 2016). Hypothetically, background noise during an exam fits the same purpose for a subgroup of the ADHD population whereas other subgroups of ADHD indeed would benefit more from a quiet and structured environment (Lee, Osborne, Hayes, & Simoes, 2008) since their ADHD symptoms are caused by different etiological factors. Finally, the Study Strategy and Experience Questionnaire also had an open-ended section where participants could leave random thoughts about the simulation exam. Some students in both the ADHD and the control group wrote down that they felt isolated, uncomfortable and stigmatized while taking the test in a separate room. Indeed, it has been reported before that (the fear of) stigma by peers and teachers makes students decide not to make use of the reasonable accommodations to which they are entitled (Lebowitz, 2013). This supports the recommendation to fully inform students with ADHD and their environment about the purpose and the procedures of reasonable accommodations prior to the exam in order to reduce discomfort and stigma (Jansen et al., 2018).

5 General discussion

Throughout their school career students with ADHD face many challenges as a result of their attentional, executive functioning, study skills and social problems (Emmers et al., 2016). Reasonable accommodations were introduced in an effort to neutralize the negative effect of environmental characteristics on the study and learning process of students with ADHD (Harrison et al., 2013). Reasonable accommodations need to be effective for the student with ADHD and fair for the peers without the disability (i.e. they should not offer an advantage to the student with ADHD) (Sireci et al., 2005). Methodological designs to study the effectiveness and fairness are often limited in the generalizability of their findings as they fail to study the effects in a naturalistic setting and to incorporate the wide range of variability in symptomatology of ADHD and teaching and evaluation methods (Jansen et al., 2017). In both the intervention and experimental study, we opted for a simulation exam with a high stakes component (i.e. top 25% is higher rewarded) and monitoring of distraction levels (i.e. the role of actors taking the exam). While our simulation seemed to be successful, several flaws became evident as well (e.g., no preparation required, shorter test duration than normal). As such the findings should be treated with caution. We can however conclude the following.

First, a test-taking strategy training slightly increases test performance, even on top of a learning effect because of taking the (parallel version of the) test twice. We observed this effect in an extended time condition but the design does not allow us to attribute the effect exclusively to the reasonable accommodation. A holistic and comprehensive approach in educational support (e.g., by focusing on test-taking strategies, planning and organization skills) seems however indicated.

Second, at least for a subgroup of the ADHD population test performance during separate room test-taking is not effective (or even counter-effective). Participants (qualitatively) referred to feeling isolated, experiencing discomfort and being stigmatized. It hints at the need of individually tailored (combinations of) reasonable accommodations (Kettler, 2012) as well as extensive informing all parties involved about the purpose and procedures. At the institution level this will however quickly reach the limits of what is reasonable and feasible.

Taken together, these findings suggest that generic evidence-based recommendations for the selection and implementation of reasonable accommodations across the school trajectory will remain (for a long time) missing. Such generic recommendations might actually be counterproductive since current educational practices often grant reasonable accommodation on the basis of (ADHD) certification rather than on individual educational needs of the student, hereby fueling discussions on fairness of the measures taken. Therefore, the full implementation of a stepped-care approach seems essential. Here, policy makers, teachers and educators first embrace practices from which all/the majority of the students will benefit. For instance, if standard exam duration is now 3 hours in higher education, one could consider offering 4 hours as the standard exam duration while keeping the length of the exam itself constant. With this practice, students with a functional disability no longer need to register for longer exam duration. This inclusive approach will thus diminish the number of students who have additional educational needs on top of common practices. Thus, in a next step, a smaller group of students with functional disabilities can then request additional reasonable accommodations. Taken from our data, training students in test-taking strategies could also be considered as part of a more holistic approach from which not just students with functional disabilities can benefit.

When adopting a stepped-care approach, it could become also more feasible to accomplish an individually tailored support plan (consisting of person-specific reasonable accommodations) in this reduced number of students.

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Samenvatting

Effectiviteit van redelijke aanpassingen bij leerlingen met ADHD: een experimenteel en interventieonderzoek

Het hoger onderwijstraject van studenten met ADHD wordt gekenmerkt door lagere prestaties, vaker dubbelen en hogere uitval dan hun leeftijdsgenoten zonder ADHD. Redelijke aanpassingen worden geïmplementeerd om aan deze situatie te verhelpen. Echter, de wetenschappelijke evidentie voor effectiviteit van redelijke aanpassingen is bijzonder beperkt, zelfs van frequent gebruikte aanpassingen zoals langere examentijd. In een interventiestudie onderzochten we of een teststrategietraining de testprestatie op een gesimuleerd examen zou verbeteren tijdens langere examenduur. Vergeleken met een standaard examenduur conditie, verbeterde de getrainde groep (n=23) zijn time-management strategieën meer dan een ongetrainde groep (n=23) en presteerde op die manier in beperkte mate ook beter in de langere examenduur conditie. Daarnaast werd in een experimentele opzet voor het eerst de effectiviteit van de aanpassing 'apart examenlokaal' nagegaan. De resultaten op een gesimuleerd examen en belevingsvragenlijst toonden zowel voor studenten met als zonder ADHD (telkens n=15) aan dat de testprestatie niet significant verschilde wanneer het examen werd afgelegd in grote groep of in een apart examenlokaal. Samen tonen deze resultaten tentatief aan dat de effectiviteit van frequent gebruikte aanpassingen voor ADHD beperkt is maar mogelijk kan versterkt worden wanneer ze onderdeel vormen van een ruimer ondersteuningspakket. Tegelijk moeten ook steeds alternatieve oplossingen overwogen worden.

Kernwoorden: redelijke aanpassingen, ADHD, training studiestrategieën, testen