

Department of Psychology

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Cognitive flexibility

 amongst patients with anorexia nervosa

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1. Introduction

Anorexia nervosa (AN) is a severe, chronic, and refractory psychiatric disorder (Klump, Bulik, Kaye, Treasure & Tyson 2009). It is characterized by self-starvation, excessive exercise, morbid eating restraint, and overvalued fear of obesity. Anxious and pathological cognitions about eating, weight, and shape are also common in the disorder (American Psychiatric Association, 2013). AN implications range across physical, cognitive and emotional levels, accompanied by a persistent pattern of behaviors to prevent restoration of normal weight (Fairburn & Harrison, 2013).

The etiology of the disease is not clear, but some risk factors were found to be more prominent. Examples include personality traits, anxiety, obsessions, inhibition, inflexibility, and perfectionism. Moreover, neurobiological characteristics were also found to be associated with the disorder, showing skewed interactions between serotonin aversive or inhibitory and dopamine reward systems (Bulik et al., 2007; Oldershaw et al., 2012).

 The mental disorders statistical and diagnostic manual (DSM-5) (American Psychiatric Association, 2013) points to two types of pathological eating behaviors in AN. One is the restricting type, in which extreme weight loss is achieved by dietary restriction and the second is known as binge-purge, that includes periodic episodes of binge-eating and purging. Over time, up to 50% of the restricting-type individuals will also develop purge and/or binge behaviors (AN-BN) while the rest remain “pure” restrictors. In both groups, psychiatric comorbidity is high and lifetime mortality rates are amongst the highest of any psychiatric disorder (Berkman et al., 2007). Prevalence estimates in general population samples range from 0.10% to 1.0% (Hoek., 1991). Johnson et al., (2003( suggest that for the overall spectrum of patients with AN, approximately 75%–85% will completely recover.

AN was studied from a variety of aspects, while the cognitive domain is one of them, its main purpose is to understand the AN characteristics in different stages of the disorder. Studies have shown neuropsychological differences between patients with AN and controls, which may be a mediator between underlying neurobiological and psychological functioning within the behavioral unit of the disease (Li & Feusner., 2013). A literature review of neuropsychological studies reveals difficulties in cognitive abilities which include poorer non-verbal performance; altered attentional styles to disorder related stimuli and perceptual processing impairment regarding body images (Reville et al., 2016). It is also revealed that this includes impairments in memory, speed of processing, decision making, working memory and concentration (Lena et al., 2004; Lozano et al., 2014; Martinez et al., 2014). However, the findings were inconsistent, therefore made it difficult to reach a clear conclusion.

Two cognitive domains showed the most consistent results and were suggested to be highly associated with patients in the acute stage and post recovery - One is weak central coherence (WCC) and the other is cognitive flexibility (CF) (‏Lozano et al., 2014; Stedal et al., 2012; Tenconi et al., 2010). AN patients showed impaired performance on tasks of CF and a weakened tendency for global perception vis a vis heightened ability toward local perception (Kanakam et al., 2013; Lang et al., 2014; Roberts et al., 2007). Nevertheless, in light of the recent understanding in cognitive neuroscience regarding the nature of types of flexibilities (‏Dajani & Uddin., 2015; Kim et al., 2012) and the relation between global and local processing (Lang, et al., 2014; Van der Hallen et al., 2015) this pattern of findings demands further investigation in order to better understand the characteristics of CF impairment in AN patients. Therefore, the current study’s main aim is to scrutinize CF by fine graining this ability to its different types, based on theoretical and empirical evidence.

 CF refers to the capacity of switching between multiple tasks effectively and to the readiness in which one can selectively switch between mental processes to generate appropriate behavioral responses (Dajani et al., 2015). Over the past two decades, a mount of studies indicated that AN patients perform poorer than healthy controls in CF tasks (Roberts et al., 2007). For example, Tchanturia (2012) carried out a study on CF among AN patients with sample size of five-hundred participants, showing that the AN groups performed significantly poorer on CF tasks. Also in a study in which a battery of neuropsychological tasks was administered to 270 women including AN patients, poor CF was found at a higher rate in the two groups (Roberts et al., 2010). Few studies suggested that the problem with CF may be a part of the risk factors for developing an eating disorder which may be linked to compulsive traits, rigidity and perfectionism. Thus, performance on CF tasks was suggested to be associated with childhood rigidity and inflexibility (Tchanturia & Morris, 2004).

 Due to the consistent results indicating a deficit in CF among AN, a wide body of research has also dealt with the question of whether difficulties in CF are state or trait markers. The accepted assumption today is that some aspects of CF sub-optimal performance in AN appear to be a trait rather than a state marker (Tchanturia et al., 2004). This assumption is based mainly on studies that have shown that difficulties in CF did not show any improvement after weight recovery (Tchanturia et al., 2004).

 Clinically, poor CF was associated with more severe ED rituals but not body mass index (Roberts & Tchanturia, 2010). In addition, research showed BMI not to be associated with errors in a cognitive test for CF for those with AN. Therefore, errors are not only a result of low weight (Tchanturia & Harrison, 2011). In addition, the difficulties in CF were also found among recovered/weight-restored subgroups of AN, suggesting that the deficit in CF might be a candidate of endophenotype (Tchanturia & Harrison, 2011, Tenconi & Santonastaso, 2010).

 As mentioned, although poor CF was found among AN recoveries, it is important to mention that in some studies, their CF was found to be less damaged compared to an acute AN patient, but always more damaged compared to healthy controls ([Steinglass](https://www.ncbi.nlm.nih.gov/pubmed/?term=Steinglass%252520JE%25255BAuthor%25255D&cauthor=true&cauthor_uid=16903136), 2006; Roberts 2010). In conclusion, poor CF is a trans-diagnostic feature related to aspects of the illness but not to malnutrition. In part it is a familial trait, and is likely involved in the maintenance of the illness (Roberts, 2010).

 CF has been widely investigated in the neuroscience field for the purpose of further understanding this ability as part of human cognition. However, it seems that in the research literature there are different labels for CF, as it is also called "task switching" or "set shifting". Furthermore, different types of CF are referred to in the same way (Dajani et al., 2015, Eslinger & Grattan, 1993; Kim et al., 2012; Wildes et al., 2014). The multiplicity of names has led to the use of many different terms to describe CF, creating great confusion. Possibly, the multiplicity of names and terms associated with CF stems from the fact that CF is a complex function that includes several types of flexibility and the different names and terms represent these different types or aspects of CF (Dajani et al., 2015; Eslinger & Grattan, 1993; Kim et al., 2012; Ravizza & Carter 2008). In fact, up until recent years different studies referred to different aspects of CF as representing the whole ability, leading to an incomplete understanding of this ability (Ravizza & Carter 2008; Wildes, 2014). Nevertheless, imaging and behavioral studies have recently shown that CF is not a uniform ability; rather, it is segmented into different types (Dajani et al., 2015; Eslinger & Grattan, 1993; Kim et al., 2012).

Although CF is often regarded as one general term, there seems to be different types of CF; Kim, Cilles, Johnson and Gold (2012) categorized those types based on brain imaging and former studies, and came up with 3 distinct CF types:

1. *Task switching* (also named reversal learning, set shifting and reactive flexibility) - In which participants must switch between tasks with different instructions. Meaning to say that they require to shift between different rules to complete the same task by changing the acquired principle. Common tasks for this type of CF are the Trail Making Test or the Brixton Spatial Anticipation test (Dajani et al., 2015; Eslinger & Grattan, 1993; Kim et al., 2012). Following the hierarchy of cognitive flexibility outlined by Bunge and Zelazo (Bunge, 2006) task switching is considered to be the most complex form of cognitive flexibility.
2. *Switching sets* (also named perceptual set shifting, attentional set shifting, spontaneous flexibility) – refers to switching attention between perceptual features of a stimulus (e.g. shape or color) in order to make a task-appropriate decision about the properties of a stimulus. Instead of switching between principles like in task switching, here the shifting is between different features of the stimulus to complete the same instruction. Common tasks for this type of CF are the Wisconsin card sorting test and Stroop (Dajani et al., 2015; Eslinger & Grattan, 1993; Kim et al., 2012). Set shifting is a lower-level form of cognitive flexibility, following the hierarchy of cognitive flexibility outlined by Bunge and Zelazo (Bunge, 2006).
3. *Stimulus–response mapping* (S-R mapping, response shifting) - refers to switching between two or more arbitrary or opposing stimulus–response (sometimes called S-R reversal paradigms). The goal remains the same (i.e. press button x for stimulus y) but the participant has to simply change the hand press to determine the switch is set (Yerys et al., 2015). The stimulus is not changing but another reaction is needed in order to achieve the same goal.

Few studies investigated the validation of the conjunction map of these distinct types of CF. Findings supporting this classification show how sub-types of CF involve different brain areas (Nagahama et al., 2001; Ravizza & Carter 2008; Rushworth et al., 2002). For example, Ravizza and Carter (2008) found that Switching sets and S-R Mapping have dissociable neural networks. They showed that DLPFC (BA 9/46) showed greater activity for S-R Mapping than for switching sets, While the dorsal premotor cortex (BA 6) showed greater activity for switching sets then S-R mapping.

 All the sub types of CF: task switching, switching sets and S-R mapping, result in slowing of response times and decreases in accuracy, a term referred to as ‘switch cost’. Switch costs have longer duration of response, thought to occur because of the time it takes to inhibit the response set of the previous task as well as the time it takes to reconfigure one’s response set to the new task. The current study will further investigate these cognitive flexibility domains in the clinical population of AN.

CF, as aforementioned, was found to be one of the two most prominent characteristics in AN patients, but it is not clear which type of CF described above relates to the decrease in performance. In a meta-analysis study of CF, AN patients showed a significantly lower mean difference compared to healthy (Roberts et al., 2007). Furthermore, task switching seems to have bigger impairments in AN patients then other types of CF tasks. Therefore, AN patient seems to be more sensitive and more prone to error in this type of flexibility (Roberts et al., 2007)[[1]](#footnote-1).

The research focused mainly on cognitive functioning of CF. In order to expand the existing knowledge on cognitive functioning in AN and to offer a new approach for understanding its role in the disease (Reville, 2016). While this domain has already been found to be related to AN, the contribution of the current research lies in the development of a broad and innovative theoretical concept of CF in AN as a general cognitive function that include different types of CF consisting of various types. Consequently, we hoped to contribute to the improvement of current cognitive remediation treatment methods aimed at assisting these patients.

In light of the mentioned above the following hypotheses suggested:

1. A) AN patients will show worse performance regarding "switch cost" than healthy population on all kinds of CF tasks (task switching, switching sets and S-R mapping).B) After controlling for Distress, age and years of education, the differences will be attenuated.
2. AN patients will exhibit a greater impairment in task switching than other types of CF.

2. Methods

*2.1 Participants and procedures*

The sample comprised 40 women aged 18 to 32; 20 were patients diagnosed with AN, and 20 were healthy women matched by age and education. One participant was excluded from the analyses because her body mass index (BMI) was above 17.5 on the day of testing. For AN individuals, there was a significant increase in BMI (t(24.78) = 5.17, p<.01) and in Brief Symptom Inventory (BSI) scores (t(37) = -8.21, p < .01). Furthermore, the lowest BMI among AN patients was M = 14.37, SD = 1.53, and in the period of lowest weight the values were M = 3.06, SD = 2.73. Members of the AN patient group, diagnosed by experienced eating disorder clinicians, were recruited from the eating disorder department at the Sheba Medical Center inpatient or outpatient units. Inclusion criteria for the AN patients were a BMI of less than 17.5, at least 12 years of education, and knowledge of the Hebrew language at a conversational level. Exclusion criteria were a diagnosis of an eating disorder not otherwise specified, a BMI of more than 17.5, and any developmental or acquired neurological disorder. The study was presented to the patients in one of their weekly meetings and volunteers could sign up afterwards. The experiment itself was conducted in an office allocated by the head of the department. The AN participants were taking medication as summarized in Table 1. The control participants were recruited via various work places, university classes, word of mouth, and online advertising on forums and social networks. For the control participants, inclusion criteria were a BMI of more than 19 and no medical history of eating disorders. Persons with a known history of learning or neurological disorders were not included in the study. At the scheduled meeting time, the subjects signed an informed consent form (see Appendix 1), completed a demographic questionnaire (see Appendix 2 in the tools section), and performed the experimental tasks. The tasks were presented in a counterbalanced order in order to reduce the effect of a task’s location in the testing sequence on performance. After completing the testing tasks, participants had the chance to ask questions about the study.

*Table 1:* Medications taken by AN participants.

|  |  |
| --- | --- |
| Medication | Frequency |
| Risperdl | 2 |
| Ratlin | 1 |
| Recital | 1 |
| Clunks | 4 |
| Phenergyn | 2 |
| Bondormin | 1 |
| Lusterle | 3 |
| Cipralex | 1 |
| Seroquel | 3 |
| Prizma | 7 |
| Trazodil | 1  |
| Deralin | 1 |
| Lorivan | 1 |
| Migraleve | 1 |
| Anafranil | 1 |
| Losec | 1 |

*2.2 Instruments*

*2.2.1 Neuropsychiatric assessment*

AN psychopathology was assessed by means of the Structured Clinical Interview for DSM-5 (SCID-5) and distress severity was evaluated with the Brief Symptom Inventory (BSI).

*Structured Clinical Interview for DSM-5 (SCID-5).* Each respondent underwent a diagnostic interview including the eating disorders section of the Structured Clinical Interview for DSM-5. Patients who were already hospitalized in the ward were not interviewed as their diagnosis had already been determined by the MD in charge.

*Brief Symptom Inventory (BSI).* The Questionnaire included 53 items. A list of physical and emotional symptoms was presented and participants were asked to rate their levels of distress resulting from each during the preceding month (Appendix 3)

*2.2.2 Neuropsychological assessment*

All participants were assessed using the following cognitive tasks: a) a stimulus-response (SR) mapping task, b) a set-shifting task, c) a task-switching task, and d) a Raven Progressive Matrices test.

*An SR reversal task was used for measuring the SR mapping function.* We used a test based on the "odd-man-out" (OMO) paradigm by Ravizza & Carter (2008). During the test, participants were seated in front of a computer screen displaying a group of four shapes (a shape could be a cross, hexagon, parallelogram, or triangle) at its center. All four shapes were of the same size (17% of the screen width and 23% of the screen height). Participants were asked to click on a green symbol if each shape appeared on the screen only once and on a red symbol if a shape repeated. After 30 trials, the instructions were reversed: participants were now asked to click on the red symbol if all shapes were unique and on the green symbol if a shape repeated. During the task, there were three instances in which a participant’s response to the same stimulus changed with the change in instructions. The test included 120 random trials. In each trial, the stimulus (a group of 4 shapes) was shown either until the participant responded, or for a maximum of 3 seconds. Then, the next trial started immediately. Participants were encouraged to work as quickly and as accurately as possible. *The “switch cost” was calculated by comparing the reaction times (RTs) and accuracy (ACC) from before and after the change in instructions.*

*The task-switching task measured the task-switching function*. We applied the "odd-man-out" (OMO) design by Ravizza & Carter (2008), which uses a task-switching paradigm to measure executive function. During the test, participants were seated in front of a computer screen that displayed a stimulus made up of a sequence of four letters (each could be a “b,” “i,” “n,” or “v”) superimposed on a sequence of four shapes (each could be a cross, hexagon, parallelogram, or triangle). All stimuli were of the same size (17% of the screen width and 23% of the screen height). The task was to determine which stimulus does not “fit in” with the others ([Figure 1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2553424/figure/F1/)). In each case, either three of the letters were identical and one stood out (while each of the shapes was unique), or three of the shapes were identical and one stood out (while the letters were unique). Each stimulus was presented either until the participant responded, or for a maximum of 3 seconds. Then, the next trial begun immediately. Responses were recorded using four keys on a computer keyboard located in a row, so that their relative locations corresponded to that of the respective stimuli. The test included 120 trials, organized in series of four, eight, and twelve. In each series, the OMO was placed at the same location. A switch series occurred when the OMO was shifted from one location to another (after four, eight, or twelve trials). The dependent variable was the difference in response time (RT) between the various series. Note that here rule information was not different from trial to trial. Responses were made with respect to the location of the OMO regardless of whether the OMO was a letter or a shape.

*Figure 1:* Examples of OMO stimuli, defined by first an “odd” letter and then an “odd” shape.

|  |  |
| --- | --- |
| image2 | The OMO is in the leftmost position: the letter "n" does not match the other letters. |
| image3 | The OMO is in the rightmost position: the parallelogram does not match the other shapes. |

*The set-shifting task measured the set shifting mapping function.* We again used the OMO version of the paradigm by Ravizza & Carter (2008). During the test, participants were seated in front a computer screen showing a group of four shapes (where each could be a cross, hexagon, parallelogram, or triangle) at its center. The four shapes were of the same size (17% of the screen width and 23% of the screen height). Participants were asked to click on a green symbol if each shape appeared only once and to click on a red symbol if a shape repeated. Participants were encouraged to work as quickly and as accurately as possible. The test included 120 trials. In each trial, the stimulus was presented either until the participant responded, or for 3 seconds maximum. Then, the next trial began immediately. The trials were organized in series of four, eight, and twelve. In each series the shapes were either all unique, or there were at least two identical shapes in each group. A switch series occurred when a series containing identical shapes in each group changed to a series containing only unique ones, or vice versa (after four, eight, or twelve trials). The dependent variable was the difference in RT between the types of series. Note that the rule was not switched from trial to trial.

*The Raven Progressive Matrices (RPM) test* (Raven, 1998) was used to obtain a general evaluation of intelligence (g factor). The test appeared on a computer screen and comprised a series of 60 drawings with a missing element (see example in Figure X). The participants were asked to select the element that logically completes the drawing from among options displayed below it by pressing a corresponding key on the keyboard. Each correct answer added one point to the score; the maximum score was 60. The estimated reliability of this test is α = .83.

3. Statistical Analysis

Preliminary analyses were carried out to verify matching and to test for between-group differences on important variables. Specifically, independent samples t-tests were performed to compare the groups’ age, BMI, and the BSI scores.

To test the hypotheses, first two multivariate analyses of covariance (MANCOVAs) were performed: one comparing the mean RT switch costs and the other comparing the mean ACC switch costs between the AN patients and the control group on the three tasks. Since a significant difference in BSI scores had been found between the groups, this variable was used as a covariate in the MANCOVA analyses. When significant effects were found in the MANCOVAs, a follow-up analysis was carried out to test whether the differences between the groups’ effect sizes were significant. To do that, we first converted eta-squared to Cohen's *d.* [[2]](#footnote-2) We then calculated the latter’s variance*. [[3]](#footnote-3)* Finally, we calculated the Z-score of the difference between each pair of effect size estimators as (d1-d2)/√V1+V2.

In the next step two logistic regression analyses were carried out to test if the unique effects evident in each task predicted the probability of being in the control versus the treatment group (1 = control, 2 = treatment). In the first analysis, the RT switch cost indices were entered as predictors; in the second, the ACC switch cost indices were used.

Additionally, we tested for intra-subject differences across the tasks. To do that, two repeated-measures analyses of covariance (ANCOVAs) were conducted, comparing RT and ACC switch costs, respectively. In these analyses the “group” variable (AN patients \ control) was used as a inter-subject independent variable and the type of task (SR mapping \ switching sets \ task switching) was used as a intra-subject independent variable. The BSI score was used as a covariant in this analysis.

4. Results

*Demographics*

The results of the comparison of clinical and demographic variables between the AN patients’ group and the control group are presented in Table 1.

*Table* 1*:* Results of t-tests comparing clinical and demographic variables of the AN patients’ group with those of the control group.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | AN group |  | Control group | T | df | Cohen's *d* |
| N | M | SD |  | N | M | SD |
| Age | 20 | 22.70 | 4.21 |  | 20 | 22.70 | 4.21 | .00 | 38 | .00 |
| Years of education | 20 | 12.90 | 1.21 |  | 20 | 12.80 | 1.11 | .27 | 38 | .09 |
| BSI | 19 | 3.10 | 0.67 |  | 20 | 1.60 | 0.46 | 8.21\*\*\* | 37 | 2.62 |
| BMI | 20 | 16.95 | 1.75 |  | 20 | 22.46 | 4.43 | 5.17\*\*\* | 24.78 | 1.64 |
| Lowest BMI | 18 | 14.37 | 1.53 |  | 14 | 20.34 | 3.39 | 5.45\*\*\* | 16.19 | 2.03 |
| Period of lowest weight1 | 17 | 3.06 | 2.73 |  |  |  |  |  |  |  |
| Period of weight loss1 | 18 | 9.81 | 9.43 |  |  |  |  |  |  |  |
| \* *p* < .05 \*\*\* *p* < .001 1 in months |

As can be seen in Table 1, the groups were successfully matched on age and education. Also, the expected between-group differences in current and lowest BMI were found. Finally, AN patients were found to have a significantly higher depression score on the BSI compared to the control participants. This variable was therefore used as a covariate in hypothesis testing.

*Hypothesis testing*

We hypothesized the following:

1. AN patients will show poorer performance, i.e., higher switch costs than controls on all three types of CF tasks (i.e., task switching, set shifting, and SR mapping).
2. AN patients will exhibit a greater increase in switch costs on the set shifting task than on the other CF tasks.

*Means comparison*

To test our hypotheses, we first compared the mean RT and ACC switch costs on all three tasks between the groups, while controlling for distress. The RT analysis revealed a significant multivariate effect for “group” (Wilk’s Lambda = .68, *F*(3,34) = 5.25, *p* < .001, η2 = .32), followed by significant univariate effects for all tasks. As can be seen in Figure 1, the mean RT switch costs were higher in the AN group compared to the control group on all three tasks. It is also evident that the largest difference was recorded for the set shifting task (η2 = .26 compared to η2 = .13 for SR mapping and η2 = .18 for task switching).

*Figure 1:* Means and SEs of the RT switch costs on the three tasks in the AN group and the control group (in standard score units) (N = 39).



A follow-up analysis was then carried out to test whether these differences between effect sizes were significant. Table 2 presents the Z-scores of the differences between effect sizes.

*Table* 2*:* Z-scores of the differences between the RT switch costs effect sizes between tasks.

|  |  |  |
| --- | --- | --- |
|  | 1 | 2 |
| 1. SR mapping (η2 = .13) |  |  |
| 2. Set shifting (η2 = .26) | .88 |  |
| 3. Task switching (η2 = .18) | .35 | .53 |

As can be seen in Table 3, no significant differences were found between the effect sizes (where Z > 1.96). The ACC analysis in turn did not reveal any significant multivariate effect for “group” (Wilk’s Lambda = .85, *F*(3,34) = 2.06, *p* = .12, η2 = .15), and no significant univariate effects were found for the tasks.

*Intra-subject comparisons*

Intra-subject comparisons of the RT switch costs across the three tasks did not reveal significant differences (*F*(2,72) = 1.05, *p* = .36, η2 = .03), nor was a significant interaction with the “group” variable found (*F*(2,72) = 1.47, *p* = .24, η2 = .04). Likewise, comparison of the ACC switch costs across the three tasks did not reveal significant differences (*F*(2,72) = .02, *p* = .98, η2 = .00), and no significant interaction with the “group” variable was found (*F*(2,72) = .29, *p* = .75, η2 = .01).

*Regression analysis*

In the next step, a logistic regression analysis was carried out in order to compare the unique effects of the RT switch cost on each task.

The regression model was found to be significant (Nagelkerke R2 = .65, χ2(3) = 26.94, *p* < .001). It successfully classified 85% of the observations. As can be seen in Table 3, the only significant effect was found for the set shifting task (β = 2.68, Exp(β) = 14.55, p < .05), indicating a larger RT switch cost in the AN group compared to the control group.

*Table* 3*:* Results of a logistic regression analysis predicting group attribution (1 = control \ 2 = AN) from RT switch costs (in standard scores) on the three tasks (N = 39).

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  | 95% CI for Odds Ratio |
|  | B(SE) | Wald χ2 | Lower | OR | Upper |
| SR mapping | .45 (.50) | .79 | .58 | 1.56 | 4.18 |
| Set shifting | 2.68 (1.10)\* | 5.94 | 1.69 | 14.55 | 125.26 |
| Task switching | 1.08 (.71) | 2.30 | .73 | 2.95 | 11.92 |
| \* *p* < .05 |

*Figure 3:* ROC curves of RT switch costs on the three tasks in the AN patients’ group and the control group.



5. Discussion

The aim of the present study was to examine if there are differences between AN patients and controls on a variety of CF performance measures.

The findings show a difference in distress levels between AN patients and the control group, indicating much higher distress among the AN patients. This finding confirms previous results described in the literature; therefore, the variable “distress” entered the analysis as a covariate. In addition, we found significant differences in performance between AN patients and controls on three types of CF tasks. These findings corroborate those of previous studies indicating difficulties with CF among AN patients (Roberts et al., 2007; Tchanturia et al., 2012; Roberts et al., 2010). These difficulties could be seen as linked to the disorder itself, in that the AN patients struggle to see their bodies in a “big picture” way, instead focusing on a specific flaw, which leads them to think that their bodies are generally defective (Bulik et al., 2005). Furthermore, impairments in CF seem to be reflected in the everyday behavior of AN patients. For example, problems with mental flexibility reduce their ability to engage fully in cognitive therapy, where different interpretative or behavioral options have to be considered by the patient (Tchanturia et al., 2004).

In this study we have found differences in performance on different types of CF tasks not explained by the “group” variable. This finding is in line with the theory proposed by Kim et al. (2012), who use it as the basis for a more rigorous and thorough examination of CF as having several sub-types. Furthermore, we found differences in performance between AN patients and controls regardless of the type of CF task. This finding supports the hypothesis that AN patients are more rigid in their thinking than the control population.

In addition, an innovation introduced in this study is checking the sensitivity of the CF types. Our literature review showed that task switching is regarded as the most sensitive CF task because it is the most complicated one. According to Bunge & Zelazo (2006), this type of task requires a flexibility in the deployment of rules that depends on the ability to represent increasingly complex hierarchies of rules in which higher-order rules operate on lower-order rules by selecting among them. Tchanturia et al. (2011) found that AN patients showed significantly poorer performance on set-shifting compared to controls in the Brixton test, which indicates a problem with task switching. Previously, Tchanturia et al. (2004) had found that the Simple Alternation factor appeared to be the most sensitive measure for detecting CF impairment in their AN patient group; this factor comprised the Trail Making and Brixton tests (both known as types of task switching).

In contrast, this study found set shifting to be more sensitive than the other CF measures investigated (i.e., than task switching and SR mapping). Poorer performance on set shifting could be seen as related to difficulties in shifting attention across different aspects of the same stimulus, which might be linked to the clinical manifestations of anorexia. In clinical presentation, the patients focus on one aspect of their body and have difficulty seeing the body as a whole; they find it hard to see beyond the aspect that is bothering them, even when they receive supportive feedback from others (Bulik et al., 2005). These difficulties relate to the perceptual abilities of AN patients. It makes sense that set shifting would be the most sensitive type of CF task in AN patients, because it is the type focusing on the perceptual aspect with which AN patients have difficulties. Our findings indicate the presence of impairments in CF among AN patients, especially related to set shifting, and this may have important implications for rehabilitation. There is the possibility that interventions aiming to remediate these specific forms of executive dysfunction may have benefits for patient management and everyday functioning. In line with the findings in this study, it may be possible to focus on perception in the cognitive treatments offered to AN patients. Previous studies have shown that cognitive therapy can be effective in treating problems related to perception; for example, Bennett-Levy & Beedie (2007) demonstrated that trainees’ self-perception of competence increases significantly during cognitive therapy training.

It should be noted that previous studies that used set shifting tasks have found significant group differences, hence supporting the findings of this study. According to these studies, AN patients showed significant impairments in perceptual set shifting compared to controls (Tchanturia et al., 2002, Steinglass at al., 2006). Specifically, Tchanturia et al. (2002) found evidence of a lack of flexibility in set shifting as measured using a perceptual task. Their hypothesis was that it may be possible to develop risk markers for AN on this basis, because the same deficit was also found in the AN recovered group.

It can be concluded that there are group differences in CF, in that AN patients exhibit less of it than controls and specifically show greater impairments on set shifting tasks.

It is interesting that although significant differences were found using logistic regression, the same correlations were not found using effect size analysis. The lack of significance of effect sizes could be attributed to the fact that greater differences may be required to be detectable by this type of statistical analysis than by logistic regression, which is more sensitive to smaller differences (Jodoin & Gierl., 2001). In addition, although we found significant differences in RTs, we did not find significant differences in accuracy. It may be that RT is more sensitive to showing significant differences then accuracy.

This study has several limitations. First, the sample size was small, which may make the findings less generalizable to the wider AN population. Therefore, using a larger sample would strengthen the results and conclusions. Second, the AN group was very homogenous in that that participants were recruited from a single eating disorder ward which tends to concentrate patients with extreme clinical characteristics. Therefore, using a variety of recruitment sources could have produced a sample representing the population more accurately. Third, although no differences were found concerning the number of years of education, further studies should take into account more accurate IQ measures to rule out differences between the groups.

 Following from this, a number of suggestions for follow-up studies can be made. First, further studies could focus on the perceptual aspects of CF, as targeting them may increase the efficacy of AN treatment. Second, future research could examine both types of pathological eating behaviors in AN (the restrictive type and the binge-purge type) in the context of CF. Third, it could be interesting to pursue further study with subjects recovered from AN.

Previous research focused on CF types in order to expand the existing knowledge on cognitive flexibility in AN and to offer a new approach to understanding their role in the disorder (Reville, 2016). The contribution of the present study with regard to CF is in identifying the CF task type most sensitive to being affected by AN in the acute stage. On the empirical level, our unique contribution consists in dividing CF into different sub-types in the context of AN, as all previous studies so far have interpreted CF as a monolithic concept. Thus, this study sheds light on the detachable nature of CF in AN patients. Finally, differentiating between the various types of CF will hopefully help to improve cognitive treatments focusing on this specific ability. We hope that this study will support a more informed use of cognitive tasks in caring for AN patients.

The current study aimed to test the differences in CF between AN patients and controls. The findings show that AN patients exhibit lower performance on CF tasks, and this difference cannot be explained by the difference in distress levels alone. Furthermore, we showed that while AN patients are more rigid in their thinking than controls on all tasks tested, set shifting is the most sensitive type of CF task. In view of the current study, it can be inferred that AN patients have a cognitive impairment in CF, as well as a more sensitive index compared to others. Therefore, further follow-up studies should continue to explore this question.

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1. Appendix

**Appendix 1: הסכמה מדעת להשתתפות במחקר**

הסכמה מדעת להשתתפות במחקר שאינו ניסוי קליני בבני אדם

אני החתום מטה:

|  |
| --- |
| שם פרטי ומשפחה: |
| מס' תעודת זהות: |
| כתובת |

1. מצהיר/ה בזה כי אני מסכים/ה להשתתף במחקר כמפורט במסמך זה.
2. מצהיר/ה בזה כי הוסבר לי על- ידי:

|  |
| --- |
| שם החוקר/**חוקר המשנה** המסביר: רינת ברנר יעקבי/ בר בן ברוך |

1. כי החוקר הראשי \_\_\_פרופ' תלמה קושניר, ד"ר אייל חלד\_\_\_קיבל מוועדת אתיקה אישור לביצוע המחקר.
2. כי המחקר נערך בנושא: מאפייני גמישות חשיבה גמישות חשיבה ועיבוד חזותי בקרב נשים המאובחנות עם אנורקיסה נרבוזה ומחלימות ממנה, בהשוואה לקבוצת נשים ללא אבחנה.
3. כי אני חופשי/ה לבחור שלא להשתתף במחקר, וכי אני חופשי/ה להפסיק בכל עת השתתפותי במחקר, כל זאת מבלי לפגוע בזכותי לקבל את הטיפול המקובל.
4. כי מובטח שזהותי האישית תשמר סודית על ידי כל העוסקים והמעורבים במחקר ולא תפורסם בכל פרסום כולל בפרסומים מדעיים.
5. כי במקרה של מילוי שאלון – אני רשאי/ת שלא לענות על כל השאלות שבשאלון או על חלק מהן.
6. הנני מצהיר/ה כי נמסר לי מידע מפורט על המחקר ובמיוחד על הפרטים הבאים המפורטים להלן/המפורטים **בדף מידע המצורף לטופס זה1**:
7. מטרות
8. הנדרש מהמשתתף במסגרת המחקר
9. אי-הנוחות העלולה להיגרם
10. הנני מצהיר/ה בזה כי הסכמתי הנ"ל נתתי מרצוני החופשי וכי הבינותי את כל האמור לעיל. כמו כן קיבלתי עותק של טופס ההסכמה מדעת ואת דף המידע המצורף לטופס זה (אם קיים).

|  |  |  |
| --- | --- | --- |
| שם המשתתף/ת במחקר | חתימת המשתתף/ת במחקר | תאריך |
|  |  |  |

הצהרת החוקר/חוקר המשנה:

|  |  |  |
| --- | --- | --- |
| שם החוקר/חוקר המשנה שהסביר: | חתימתו | תאריך |
|  |  |  |

**1 את המידע בסעיף ג' מומלץ לפרט בדף מידע נפרד שיצורף לטופס זה**

נספח לסעיף ג'- דף מידע:

במחקר הנוכחי ננסה לבחון היבטים שונים ביכולות החשיבה בקרב נשים המאובחנות בהווה ובעבר בהפרעת האכילה אנורקסיה נרבוזה. מחקרים מעידים על כך שאצל המאובחנות במחלה קיים קושי בגמישות חשיבה, כלומר ביכולת לנוע מנושא אחד לאחר, ובעיבוד תפיסתי - בנטייה להתייחס קודם כל לפרטים של חפץ או אדם שמסתכלים עליו, להבדיל מלכולו (לשלם).

במחקר הנוכחי ננסה לבדוק ממצאים אלו בצורה עמוקה יותר על ידי בחינת סוגים של גמישות חשיבה, ובחינה מעמיקה של מאפייני העיבוד התפיסתי שתוארו. כמו כן נרצה לבחון האם נשים שהחלימו מהמחלה נבדלות מחולות בה ומכאלה שלא אובחנו, בהיבטים הללו. חשיבות המחקר היא בהבנה עמוקה יותר של מאפייניה הקוגניטיביים של המחלה.

אנו מודים ומעריכים את נכונותך להשתתף במחקר ולתרום להרחבת הידע הקיים. במחקר זה תתבקשי לענות על מספר שאלונים וכן על מספר משימות ממוחשבות. על פי רוב המשתתפות מסיימות את מטלות הניסוי ללא קושי ,אולם לעיתים תיתכן תחושת עומס נוכח ההתמודדות עם המשימות הממוחשבות השונות. בכל שלב ניתן להפסיק את הניסוי או לקחת הפסקה.

Appendix 2: Demographic, personal, and exercise data

1) תאריך מילוי השאלון:\_\_\_\_\_\_\_\_\_

2) תאריך לידה:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3) עיסוק:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4) מצב משפחתי: )הקיפי בעיגול)א. רווקהב. נשואה

ג. אחר, פרטי:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5) מוצא עדתי: (הקיפי בעיגול) א. אשכנזי

ב. מזרחי

ג. מעורב

ד. אחר, פרט:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6) מספר האחים ושנת לידה של כל אחד מהם:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7) מספר האחיות ושנת לידה של כל אחת מהן:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8) דת: (הקיפי בעיגול) א. יהודית

 ב. נוצרית

 ג. מוסלמית

 ד. אחר, פרטי:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9) השכלת האב: (הקיפי בעיגול) א. בית ספר יסודי

ב. בית ספר תיכון

ג. תואר ראשון

 ד. תואר שני

ה. תואר שלישי

10) השכלת האם: (הקיפי בעיגול) א. בית ספר יסודי

 ב. בית ספר תיכון

 ג. תואר ראשון

 ד. תואר שני

ה. תואר שלישי

11) איך היית מגדירה את הורייך? (הקיפי בעיגול)

 א. דתיים

 ב. מסורתיים

 ג. חילוניים

 ד. אחר, פרטי:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

12) איך היית מגדירה את עצמך? (הקיפי בעיגול)

 א. דתיה

ב . מסורתית

 ג. חילונית

ד. אחר, פרטי:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13) גובה:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14) תוספת הגובה בשלוש השנים האחרונות:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15) משקל:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

16) משקל רצוי/אידיאלי:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

17) משקלך הגבוה ביותר עד כה:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ חודש ושנה:\_\_\_\_\_\_\_\_\_\_\_\_

18) משקלך הנמוך ביותר בשלוש השנים האחרונות:\_\_\_\_\_\_\_\_\_ חודש ושנה:\_\_\_\_\_\_\_\_\_\_\_

19) האם את נוטלת גלולות? (הקיפי בעיגול(

 א. לא

 ב. כן, איזה?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ממתי? (חודש ושנה)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

20) הגיל שבו הופיע המחזור הראשון:\_\_\_\_\_\_\_\_\_\_\_\_\_\_

21) האם המחזור שלך סדיר? (הקיפי בעיגול)

 א. כן

 ב. לא, פרטי:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

22) האם את עוסקת באופן סדיר בספורט או בפעילות גופנית כלשהי? )הקיפי בעיגול)

 א. לא

 ב. כן – פרטי את סוג הפעילות

פעילות עיקרית:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ מספר שעות בשבוע:\_\_\_\_\_\_\_\_\_

פעילות אחרת:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ מספר שעות בשבוע:\_\_\_\_\_\_\_\_\_

כמה שנים את עוסקת בפעילות הזו?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

23) האם את עסקת בעבר באופן סדיר בספורט או בפעילות גופנית כלשהי? (הקיפי בעיגול)

 א. לא

 ב. כן – פרטי את סוג הפעילות

פעילות עיקרית:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ מספר שעות בשבוע:\_\_\_\_\_\_\_\_\_

פעילות אחרת:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ מספר שעות בשבוע:\_\_\_\_\_\_\_\_\_\_

במשך כמה שנים עסקת בפעילות הזו?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

24) האם את מעשנת? א. לא

 ב. כן כמה סיגריות ליום?\_\_\_\_\_\_\_\_\_\_\_\_\_

 באיזה שנה התחלת?\_\_\_\_\_\_\_\_\_\_\_\_\_

25) האם עישנת בעבר? א. לא

 ב. כן במשך כמה שנים?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 כמה סיגריות ליום?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Appendix 3: BSI (Brief symptom inventory)**

לפנייך שאלון המורכב מ-53 פריטים, המבטאים סימפטומים פסיכולוגיים שונים. אנא דרגי באיזו מידה סבלת מכל אחד מהסימפטומים הללו **בחודש האחרון.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **1."בכלל לא"** | **2. "מעט"** | **3."בינוני"** | **4."די הרבה"** | **5."במידה רבה מאוד"** |
| **1.** | עצבנות |  |  |  |  |  |
| **2.** | הרגשת עלפון או סחרחורת |  |  |  |  |  |
| **3.** | מחשבה שמישהו אחר יכול לשלוט על מחשבותייך |  |  |  |  |  |
| **4.** | הרגשה שאחרים אשמים בבעיות שלך |  |  |  |  |  |
| **5.** | קשיים בזיכרון |  |  |  |  |  |
| **6.** | רוגז ועצבנות מהירים |  |  |  |  |  |
| **7.** | כאבים בלב או בחזה |  |  |  |  |  |
| **8.** | פחד ממקומות פתוחים |  |  |  |  |  |
| **9.** | מחשבות לשים קץ לחייך |  |  |  |  |  |
| **10.** | הרגשה שאי אפשר לסמוך על אחרים |  |  |  |  |  |
| **11.** | חוסר תיאבון |  |  |  |  |  |
| **12.** | הרגשת פחד פתאומי ללא סיבה |  |  |  |  |  |
| **13.** | התפרצויות זעם שלא יכולת לשלוט בהן |  |  |  |  |  |
| **14.** | הרגשת בדידות גם כשהנך בחברת אנשים |  |  |  |  |  |
| **15.** | הרגשה שמשהו מפריע לך לבצע דברים |  |  |  |  |  |
| **16.** | הרגשת בדידות |  |  |  |  |  |
| **17.** | הרגשה שאת מצוברחת |  |  |  |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **18.** | חוסר עניין בדברים |  |  |  |  |  |
| **19.** | הרגשת פחד |  |  |  |  |  |
| **20.** | הרגשה שהנך נפגעת בקלות |  |  |  |  |  |
| **21.** | הרגשה שאנשים אינם ידידותיים או מסמפתים אותך |  |  |  |  |  |
| **22.** | הרגשה שהנך נחותה מאחרים |  |  |  |  |  |
| **23.** | בחילה או אי שקט בבטן |  |  |  |  |  |
| **24.** | הרגשה שאנשים מסתכלים או מדברים עלייך |  |  |  |  |  |
| **25.** | קושי להירדם |  |  |  |  |  |
| **26.** | צורך לחזור ולבדוק מה שעשית |  |  |  |  |  |
| **27.** | קושי בקבלת החלטה |  |  |  |  |  |
| **28.** | פחד לנסוע באוטובוס או ברכבת |  |  |  |  |  |
| **30.** | קושי בנשימה |  |  |  |  |  |
| **31.** | גלי חום או קור |  |  |  |  |  |
| **32.** | צורך להימנע ממקומות או מפעולות אשר מפחידים אותך |  |  |  |  |  |
| **33.** | הרגשה שהראש נעשה ריק |  |  |  |  |  |
| **34.** | הרגשה שהגפיים כאילו מאובנות או דקירות בחלקים שונים של הגוף |  |  |  |  |  |
| **35.** | מחשבה שמגיע לך עונש על חטאייך |  |  |  |  |  |
| **36.** | קשיי ריכוז |  |  |  |  |  |
| **37.** | הרגשת חולשה בחלקים מגופך |  |  |  |  |  |
| **38.** | הרגשת מתח |  |  |  |  |  |
| **39.** | מחשבות על מוות |  |  |  |  |  |
| **40.** | דחף להכות לפצוע או להזיק למישהו |  |  |  |  |  |
| **41.** | דחף לשבור ולהפוך דברים |  |  |  |  |  |
| **42.** | הרגשת אי נוחות פנימית |  |  |  |  |  |
| **43.** | הרגשת מבוכה במקום הומה אדם |  |  |  |  |  |
| **44.** | חוסר הרגשת קרבה לאנשים |  |  |  |  |  |
| **45.** | התקפי פחד או פאניקה |  |  |  |  |  |
| **46.** | כניסה מהירה לויכוחים |  |  |  |  |  |
| **47.** | הרגשת עצבנות כשהנך נשארת לבד |  |  |  |  |  |
| **48.** | הרגשה שאחרים אינם מעריכים כראוי את הישגייך |  |  |  |  |  |
| **49.** | חוסר שקט כזה שאינך יכולה לשבת במקום אחד |  |  |  |  |  |
| **50.** | הרגשת חוסר ערך |  |  |  |  |  |
| **51.** | הרגשה שאנשים ינצלו אותך(אם תיתני להם) |  |  |  |  |  |
| **52.** | הרגשות אשמה |  |  |  |  |  |
| **53.** | הרגשה שמשהו לא בסדר עם הראש שלך |  |  |  |  |  |

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1. This conclusion was concluded by calculation mean of each cognitive flexibility type. [↑](#footnote-ref-1)
2. *d*= √(η2/(1- η2))\*2 (Cohen, 1988) [↑](#footnote-ref-2)
3. Var(*d*)= (N1+N2)/ (N1\*N2)+d2/(2\*(N1+N2-2)) (Hedges, 1981) [↑](#footnote-ref-3)