

Department of Psychology

Graduate program in Rehabilitation Psychology

Research proposal submitted in partial fulfillment of the requirements for the M.A degree in psychology

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. Method

*2.1 Participants and procedures*

The sample was composed of 40 women aged 18 to 32; 20 were patients diagnosed with AN, and 20 were healthy women with matched age and education. One participant was excluded in the analyses, because her body mass indices (BMI) were above 17.5 on the day of testing. For AN individuals, there was a significant increase in body mass index (BMI) (t(24.78)=5.17, p<.01) and in brief symptom inventory (BSI) (t(37)=-8.21, p<.01). Furthermore, the lowest BMI of AN patients was M = 14.37, SD = 1.53, M, and in period of lowest weight the M = 3.06, SD= 2.73. An AN patient group, diagnosed by experienced eating disorders clinicians, were recruited from the eating disorder department at 'Sheba' Medical Center inpatient or outpatient units. Inclusion criteria for the AN patients were: a diagnosis of BMI (body mass index) below 17.5, at least 12 years of education and Hebrew at the level of speaking. Exclusion criteria were: a diagnosis of AN not other way specified, BMI above 17.5 and any developmental or acquired neurologic disorder. The study was presented to the patients in one of their weekly gatherings and any patient could choose to sign up afterwards. The experiment itself was conducted in an office allocated by the head of the department. The AN participants were taking medicine, as the table shows. Healthy participants were recruited through different work places, university classes, word of mouth, and through online advertising, in forums and social networks. For the healthy participants inclusion criteria were: BMI above 19 with no medical history of any eating disorder. Persons with a known history of learning disorders, or a neurological disease were not included in the study. After scheduling a meeting, the examinees signed an informed consent form (see appendix 1), completed a demographic questionnaire (see appendix 2) in the tools section, and performed the tasks. The tasks were presented in a counterbalanced order, to reduce test location effect on performance. At the end of assignments, the participants had the chance to ask questions regarding the study.

*Table 1:* AN Participants medications

|  |  |
| --- | --- |
| 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 was undergoing a diagnostic interview including the eating disorders section of the Structured Clinical Interview for DSM-5. Patients that were already hospitalized in the ward, weren’t interviewed as their diagnosis was determined by the MD in the ward.

*BSI (Brief symptom inventory).* The Questionnaire included 53 items. Participants were asked to refer to various physical and emotional problems and complaints and rate their degree of suffering from each problem during the preceding month (Appendix 3)

*2.2.2 Neuropsychological assessment:*

All participants were assessed using the following cognitive tasks: a) an S-R mapping task, b) a Set-shifting task, c) a Task-switching task, and d) a Raven Progressive Matrices test.

*The S-R Reversal Task was used for measuring the S-R mapping function.* We have used a test based on the "odd-man-out" (OMO) Ravizza & Carter design (2008). During the test, participants were sitting in front of a computer screen that showed four shapes (a cross, a hexagon, a parallelogram, and a triangle) which appeared in the center of the screen. The four shapes were of the same size (17% width and 23% height). Participants have been asked to click on the green mark if all the shapes were different and to click on the red mark if the screen contained at least two similar shapes. After 30 trials, the instructions were reversed. Participants were asked to click on the red mark if all the shapes were different and to click on the green mark if at least two shapes were perceived as similar. During this task, there were three cases in which participants' respond to the same stimuli would change with the change in instructions. The test included 120 random trials. In each trial, the stimuli (the shapes of a cross, hexagon, parallelogram, and triangle) were shown until the participant responded in fewer than three seconds. Then, the next trial has begun immediately. Participants were encouraged to work as quickly and as accurately as possible. Measurement of the *"switch cost" were made by comparing reaction times and accuracy before and after the change in instructions.*

*The Task-switching; Task measures the task-switching function*. We applied the "odd-man-out" (OMO) Ravizza & Carter design (2008) that uses a task-switching paradigm to measure executive function.  During the test, participants were sitting in front of a computer screen where letters (i.e., b, i, n, v) and four shapes (i.e., cross, hexagon, parallelogram, and triangle) comprised the stimulus set. All the stimuli were of the same size (17% width and 23% height).The task had to determine which stimulus didn't match the others ([Figure 1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2553424/figure/F1/)). Three of the stimuli were identical and one wasn’t. Stimuli were presented until the participant responds in less than three seconds. The next trial then has begun immediately. During the test, keys that were in a row on a computer keyboard collected the responses. The test included 120 trials, organized in series of four, eight and twelve. In each series, the OMO is placed in 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 change in response time (RT) among the various series. Note that 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 is a letter or a shape.

*Figure 1:* Examples of the OMO, moving from letters to shapes.

|  |  |
| --- | --- |
| image2 | The OMO is in the most left position. The letter "n" does not match the other letters. |
| image3 | The OMO is in the most right position. The parallelogram does not match the other shapes. |

*The Set-Shifting: Task that measured the set-shifting mapping function.* The "odd-man-out" (OMO) version of the Ravizza & Carter paradigm (2008) were used. During the test, participants were sitting in front a computer screen that were showing four shapes (a cross, a hexagon, a parallelogram, and a triangle) which appeared in the center of the screen. The four shapes were of the same size (width 17% and height 23%). Participants were asked to click on the green mark if all shapes were different and to click on the red mark if at least two shapes were similar. Participants were encouraged to work as quickly and as accurately as possible. The test included 120 trials. In each trial, the stimuli (four shapes - a cross, hexagon, parallelogram, and triangle) were presented until the participant responded in fewer than three seconds. The next trial then begun immediately. The trials were organized in series of four, eight, and twelve. In each series the shapes were either all different or there were at least two similar shapes. A switch series occurred when series of similar shapes changed to series of different ones and vice versa (after four, eight, or twelve trials). The dependent variable was the change in response time (RT) among the various series. Noted that the information rule was not switched from trial to trial.

*The Raven Progressive Matrices (RPM) Test* (Raven, 1998) were used to obtain a general evaluation of intelligence capacity (g factor). The test, appeared on a computer screen and composed a series of 60 diagrams or designs that had a missing part (see example in Figure X). The participants were asked to select the option that completes the design from those found below the design by pressing the appropriate mark on the keyboard. For each correct answer the score was one, while the maximum score was 60. The estimated reliability is α=.83.

3. Statistical Analysis

Preliminary analyses were performed to verify matching and test differences on important variables between the groups. Specifically, independent samples t-test were performed comparing age, BMI and the Distress (BSI) score.

To test the hypotheses two MANCOVAs (multivariate analyses of covariance) were firstly performed, one comparing the mean RT and the other comparing the mean ACC switch costs of the three tasks, between the AN patients and the control group. As a significant difference was found between the groups on the BSI score, 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 sizes of those effects are significant. To do that we will firstly convert eta squared to Cohen's *d* [[2]](#footnote-2) . Secondly we calculated the variance of Cohen's *d [[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 compare the unique effects of each task, predicting the odds 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 and in the other - the ACC switch cost indices.

Additionally, we tested the intra-subject differences between the tasks. To do that, two Repeated Measures ANCOVAs (analysis of covariance) were conducted, one comparing RT switch costs and the other comparing ACC switch costs. In those analyses group (AN patients\ control) was used as a between-subjects IV and type of task (S-R mapping\ Switching sets\ Task switching) was as a within-subjects IV. BSI score was used as a covariant in this analysis.

4. Results

*Demographics*

Results of the comparisons 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 and the control group.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Treatment 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 month |

As can be seen in table 1, there was a successful match between age and education. Also, the expected difference in current and lowest BMI was found. Finally, AN patients were found to have a significantly higher Depression BSI is a distress indication and depression compared with the control participants. This variable was therefore used as a covariate in hypotheses testing.

*Hypotheses testing*

We hypothesized that:

1. AN patients will show worse performance regarding "switch cost" than healthy population on all three types of CF tasks (i.e., task switching, switching sets and S-R mapping).
2. AN patients will exhibit a greater impairment in switching sets’ switch cost, than other types of CF.

*Means comparison*

To test our hypotheses we firstly compared the means of the reaction time (RT) and the accuracy score (ACC) switch costs in all three tasks between the groups, while controlling for distress. The RT analysis revealed a significant multivariate effect for group type (Wilk’s Lambda=.68, *F*(3,34)=5.25, *p*<.001, η2=.32), followed by significant univariate effects for all the tasks. As can be seen in figure 1, mean RT switch cost was larger in the AN patients group, compared with the healthy group in all three tasks. It can also be seen that the largest difference was recorded for the switching sets task (η2=.26 compared with η2=.13 for S-R mapping and η2=.18 for task switching).

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



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

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

|  |  |  |
| --- | --- | --- |
|  | 1 | 2 |
| 1. S-R mapping (η2=.13) |  |  |
| 2. Switching sets (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). As to the ACC analysis, it did not reveal a significant multivariate effect for group type (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*

Within subject comparison of the RT switch costs between the three tasks, did not reveal a significant difference (*F*(2,72)=1.05, *p*=.36, η2=.03), nor a significant interaction was found with group type (*F*(2,72)=1.47, *p*=.24, η2=.04). Likewise, comparison of the ACC switch costs between the three tasks did not reveal a significant difference (*F*(2,72)=.02, *p*=.98, η2=.00), and no significant interaction was found with group type (*F*(2,72)=.29, *p*=.75, η2=.01).

*Regression analysis*

In the next step a logistic regression analysis was conducted in order to compare the unique effects of the RT switch cost of 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 one significant effect was found - for the Switching sets task (β = 2.68, Exp(β)=14.55, p < .05), indicating a larger RT switch cost in the AN patients group compared with the control.

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

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  | 95% CI for Odds Ratio |
|  | B(SE) | Wald χ2 | Lower | OR | Upper |
| S-R mapping | .45 (.50) | .79 | .58 | 1.56 | 4.18 |
| Switching sets | 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 of the three tasks in the AN patients and the control groups



5. Discussion

The aim of the current study was to examine if there is difference between AN patients and healthy controls in variety types of CF performants.

The findings show that there was a difference in the level of distress between AN patients and healthy population, indicating much higher distress among the AN patients. This finding fits with the known in the literature, therefore the variable Distress entered as a covariate in the analysis. In addition, we found that there is difference between the types of CF in AN patients and healthy population. These finding reinforces the known from the literature indicating difficultness in CF among AN patient Roberts et al., 2007; Tchanturia et al., 2012; Roberts et al., 2010) These difficulties are linked to the disorder that the suffers from so that the AN patients struggle with seeing the whole picture of her or his body while focusing on a specific flaw, which leads them to think that their body is 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 the 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 between different CF types, beyond the variable of the the population. This finding in line with the theory of Kim et al., (2012), which used as a means for a more rigorous and thorough examination of the CF as more than one type. Furthermore, there are differences between AN patients and healthy population beyond the variable CF type. This finding supports that AN patients are more rigid in their thinking than a healthy population.

In addition, the innovation of this study is shown by checking the sensitivity of the CF types. The literature review showed that task switching is the most sensitive type in CF because it the most complicated type. According to Bunge & Zelazo, (2006) this type require correspondence between the development of rule use 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 in comparison to controls in the Brixton Test, which indicated on a problem in task switching. In Tchanturia et al (2004) Study, they found that The Simple Alternation factor proved to be the most sensitive in detecting impairment in the anorexia nervosa group and this comprised the Trail Making and Brixton tests (both known as task switching).

In contrary, this study has found that switching sets are the most sensitive type than the other (Task switching and SR mapping). It can be assumed that switching sets refers to the difficulties in flexibility between other kind of aspects by the same stimulus and it might be linked to clinical manifestation of anorexia. According to the clinical appearance, the patients focusing on one organ in their body and they have difficulty to see the body as a whole. They find it hard to see beyond the organ that is bothering them, although they received other information from others (Bulik et al., 2005). These difficulties related to perception aspect among AN patients. It makes sense that switching sets is the most sensitive type of CF in AN patients, because it is the type whom focuses on the perceptual aspect, which AN patients have difficulties. Our findings indicate that there is impairment in CF among AN patients, more specific in switching sets type, and it is may have important implications for rehabilitation. There is a possibility that attempts to remediate specific executive dysfunction may have benefits on patient management and everyday functioning. In line with the finding in this study, it may be possible to focus on perception in the AN patients cognitive treatment. There are studies that have shown that cognitive therapy is effective in treating the perception aspect. For example, Bennett-Levy & Beedie (2007), demonstrated that trainees’ self-perception of competence increases significantly during cognitive therapy training.

It should be noted that there are studies that have been using switching sets tasks and found significant differences, hence supporting the findings of this study. According to these studies, the AN patients had significantly impaired in perceptual set shifting (as known in this study as switching sets) than the controls (Tchanturia et al., 2002, Steinglass at al., 2006). According to Tchanturia et al (2002) they found evidence of a lack of flexibility in set shifting as reflected in the perceptual task. their hypothesis was that it may be possible to develop markers of risk for the development of AN because the same deficit was also found in the ANR recovered group.

It can be concluded that there are gaps in CF so that AN patients exhibits greater cognitive inflexibility than healthy population and more specifically greater impaired in the type of switching sets.

Interesting is that Although there were significant gaps compared to logistic regression, the same correlation was not found under effect sizes analysis. The lack of significant in effect sizes can be attributed to the fact that greater differences may be needed in this kind of statistical technique than the logistic regression which is more sensitive to smaller differences (Jodoin & Gierl., 2001). In addition, although we found significant differences in response time, we did not find significant difference in accuracy. It may be that response time is more sensitive to find significant difference then accuracy.

This study has several limitations. First, the sample size was too small, which indicates that the findings may be less generalizable to wider AN population. Therefore, enlargement of the sample would strengthen the results and conclusions. Second, the type of AN participants was too homogenous, such that they were taken from an eating disorder department, in which the clinical characteristics of these patients incline to extremity. Therefore, other sources of allocations could have better reflected the population. Third, although no differences were found about the amount of years of education, further studies should take into account much accurate measures IQ of the subjects to rule out gaps between the groups.

 Following on from this, a number of suggestions for follow-up studies are presented: First, further studies to focus on the perceptual aspect that may increasing the efficacy of AN treatment. Second, examine both types of pathological eating behaviors in AN (restricting type and binge-purge type) in the context of CF. Third, it could be interesting to do further study with anorexia recoveries subjects.

The research focused on CF types, in order to expand the existing knowledge on cognitive flexibility in AN and to offer a new approach of understanding their role in the disorder (Reville, 2016). The current study’s contribution with regard to CF is in identifying the most sensitive CF type of AN in the acute stage. On the empirical level, the study's contribution was by dividing CF into different types, as all studies to this day interpreted CF as a monolithic concept. Thus, the shed light on the detachable nature of CF in AN patients. Finally, distinguishing between different types of CF will hopefully help to improve cognitive treatments focusing on this specific ability. We hope that this study will help to make more informed use of cognitive tasks in care in AN patients.

The current study aimed to test the differences in CF between AN patient and healthy controls. The findings of the study showed that AN patients has a more impaired CF and this was displayed beyond the level of distress they owe. Furthermore, we showed that AN patients are more rigid in their thinking than a healthy population, but above this switching sets are the most sensitive type of CF. In view of the current study, it can be inferred that AN patients have a cognitive impairment in CF, as well as have 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)