NORTHERN ILLINOIS UNIVERSITY

Does performing APT-II on a non-brain-damaged individual lead to significant changes in attention and memory skills compared to an individual with mild cognitive impairment?

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By
Audrey Allen

DeKalb, Illinois

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Does performing APT-II on a non-brain-damaged individual lead to significant changes in attention and memory skills compared to an individual with mild cognitive impairment?

Student Name (print or type)  Audrey Allen

Faculty Supervisor (print or type)  Dr. Jamie Mayer

Faculty Approval Signature  

Department of (print or type)  Allied Health & Communicative Disorders

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AUTHOR: Audrey Allen

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ABSTRACT

This project proposes to examine the quantitative and qualitative effects of Attention Process Training-II, a cognitive treatment program for attention, on a non-brain-damaged individual compared to an individual with mild cognitive impairment. My study will be an extension of Dr. Jamie Mayer’s treatment program on an individual with MCI/CADASIL, a mild cognitive impairment due to a genetic form of vascular dementia. I collected data on a non-brain-damaged individual following the same treatment program as the previous study by Dr. Mayer. This will provide a comparison control for the data collected from the individual with CADASIL. Completing APT-II with a control subject will give me experience in utilizing treatment that has not been shown to be efficacious and yet is not routinely used by Speech Pathologists. I will gain an understanding about APT-II and its effects on an individual. My goal is to learn about the nature and treatment of cognitive skills.

The purpose for my study was to compare the results of the treatment with the individual with MCI/CADASIL to data gathered from a non-brain damaged control. My treatment data will provide a comparison control for Dr. Mayer to compare to her study. A secondary purpose of my study is to determine if the application of a cognitive training program such as APT-II has the potential to improve cognitive skills even in non-brain damaged individuals. The hypothesis was that the treatment improved the cognitive skills of the client with MCI in the same fashion that it aided the client of normal development.
BACKGROUND

CADASIL stands for, “Cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy” (Rufa et al., 2007). It is an inherited disorder, triggered by alterations in the Notch3 gene. This disorder is characterized by recurrent strokes, migraines, cognitive impairment and psychiatric disturbances. Sometimes, sudden death can occur in patients with CADASIL. The condition usually manifests between the ages of 30-50 in patients, with recurrent episodes of stroke or transient ischemic attacks. Transient ischemic attacks are also known as “mini-strokes” where there is a disruption of the blood flow to the brain with symptoms that last for only a few minutes (Granild-Jensen et al., 2009). Because magnetic resonance imaging (MRI) is sensitive in displaying diffuse subcortical white matter abnormalities (Bruening et al., 2001) it is the most appropriate means to monitor the cerebral pathology of CADASIL. There are alterations in small vessels which possibly cause severe vessel stenosis, resulting in prolonged periods of limited blood supply. This condition results in a steady progression of cognitive impairment leading to dementia and increasing disability (Bruening et al., 2001). Currently there is no evidence based treatment to assist those with CADASIL (CADASIL Foundation, 2010).

MCI is said to be the transitional stage between normal aging and dementia or Alzheimer's disease. MCI is a term given to those who do not fit the profile of having Alzheimer's but show deficits in cognitive functioning when compared to those of the same age and education level. “MCI generally refers to cognitive impairment that exceeds expectations for age and education level and that occurs among otherwise normally functioning older adults.” (Lingler et al., 2006). MCI can be very hard to diagnose due to the subtleties in cognitive function, especially in high-functioning individuals. An individual with MCI usually maintains the skills used for activities such as bathing, eating and getting dressed when first symptoms of cognitive decline arise. More
complex high-functioning tasks such as organizing work, managing finances or using public transportation become impaired because they depend on memory and attention, which decline in MCI. Using MRI is an efficient way to diagnose someone who may have MCI because the most non-invasive procedure is preferred. Some individuals may recover on their own after a short period of time, but others may need life-long treatment to aid in regaining the skills that are being lost. This treatment can help the individual increase their cognitive ability. The treatment for MCI may also help those who lose cognitive function due to CADASIL. MCI and CADASIL are so closely related in regards to cognitive functioning of the individual that the same treatment protocol can be used to result in improvements made in cognition. MCI treatment is an area of increasing research. Therefore, perhaps principles used to treat MCI patients can be applied to those with CADASIL, which due to its rarity is much less well-studied.

Attention Process Training (APT-II) (Sohlberg et al., 1994) is a treatment program consisting of basic and complex cognitive functions that assist in selecting and controlling external or internal stimuli for only a moment or after extended periods of time. The Attention Process Training Programs (APT) by Sohlberg et al. (1994) are designed for adolescents, adults and veterans with mild, moderate and severe traumatic brain injury (TBI) and for those with post concussion syndrome. Murray et al. (2006) describes the focus of the treatment program as, “More basic attention functions include being alert enough to respond to stimulation and being able to sustain or maintain attention to a task or stimulus over time; complex attention functions allow us to switch rapidly our attention focus and to respond simultaneously to multiple tasks or stimuli.” Sohlberg et al. (1994) describe deficits in memory and learning as being frequent consequences of impaired attentional processing. APT provides a variety of treatment activities which train the basic attentional components essential to new learning. There are four levels or components of attention addressed in the APT Programs. The types of
cognitive tasks in the treatment program include sustained attention, selective attention, attention switching and divided attention. Sustained attention is the ability to maintain a consistent behavioral response during continuous or repetitive activities. Selective attention is the ability to maintain attention on a certain task which requires activation and inhibition of responses dependent upon stimuli. Alternating attention is the ability to switch between tasks having different cognitive requirements. Divided attention is the ability to respond to multiple tasks at the same time. The hypothesis is that the treatment protocol would allow for enough progress to assist the individual with everyday activities and will aid him in maintaining memory and attention skills. The treatment would improve cognitive abilities on tests of attention, memory, and executive functioning in everyday activities.

METHOD

A. Subjects

Client with CADASIL

Dr. Jamie Mayer and Lilli Bishop conducted a cognitive training procedure on an individual with mild cognitive impairment as a result of CADASIL. Their study, "Cognitive training in CADASIL: Can APT-II build cognitive reserve?" included, "a 58-year old male diagnosed with probable CADASIL and a history of multiple small-vessel ischemic infarctions resulting in mild, high-level cognitive deficits characterized primarily by slowed processing, attentional and executive dysfunction" (Mayer & Bishop, 2009). This client’s initials were changed to SB. The treatment design was based on SB’s needs in everyday living activities. My research was a normative comparison to this study in order to provide comparative data to show the normative pattern of progress in executive function.
Normative Study

The normative study involved a 62 year-old male with normal cognitive function. The participant, whose initials have been changed to DC, provided informed consent and was aware of the extensive testing that was to be involved. This study was approved by the Institutional Review Board at Northern Illinois University.

B. Baseline Testing

The first step in this study involved the baseline testing. The tests used in the baseline testing were the Rivermead Behavioral Memory Test (RBMT-3) (Wilson et al., 2008), the Test of Everyday Attention (TEA) (Robertson et al., 1994), the Test of Nonverbal Intelligence (TONI-3) (Brown et al., 1997), the Delis-Kaplan Executive Function System (D-KEFS) (Delis et al., 2001), and the APT-II Questionnaire (Sohlberg et al., 1994). The RBMT-3 is a highly sensitive test of everyday memory impairment. It is intended to predict everyday memory problems in people with acquired, nonprogressive brain injury and to monitor their change over time. This test is especially helpful because we can see the change in memory from baseline to the post-treatment testing (Wilson et al., 2008). The TEA gives broad measures of selective attention, sustained attention and attentional switching. This test detects change in memory for the normal population as well as finding breakdowns in attentional memory (Robertson, et al. 1994). According to Robertson, the TEA is based on real life scenarios and is very relevant to everyday attention.

The TONI-3 is a test designed to assess intelligence, reasoning, and problem solving. This test does not require language use at all, with nonverbal and relatively motor-free answering (Brown et al., 1997). D-KEFS is a system to assess higher level functioning in children and adults (Delis et al., 2001). This test has a game-like format to avoid frustration in children and adults while taking the test. The D-KEFS examines the
integrity of the frontal lobe and its functioning. Finally, the APT-II Questionnaire was
designed to assess DC’s perception of his everyday cognitive functioning. There are
questions that refer to cognitive functioning on a daily basis and what the client believes
he or she struggles with.

Initial baselines were also taken to evaluate working memory using an n-back
task. An n-back task is where the volunteer is required to monitor a series of stimuli and
to respond whenever a stimulus is presented that is the same as the one presented n
trials previously, where n is a pre-specified integer, usually 1, 2, or 3 (Owen et al., 2005).
The tests used in this study were 2-back faces, 2-back HI and 2-back LOW (Mayer &
Murray, in prep). If the faces, high frequency pictures, and low frequency pictures tests
improve, then this may show the treatment design had some effect on cognitive
functioning.

C. Baselines and Probes

A visual working memory probe, 2-back HI, was administered at every other
treatment session (i.e. once per week). This probe includes pictures of high frequency
words. The 2-back LO and 2-back Faces probes were used as exposure controls and
thus administered only at baseline and again in post-treatment.

Client DC performed within normal limits for most of the pre-treatment testing.
The only test on which he demonstrated below-average performance was the Color-
Word Interference portion of the D-KEFS test.

D. Treatment

The treatment was a single subject multiple baseline study design. APT-II was
used as the treatment design for my study which includes visual and auditory methods of
cognitive retraining that assist with sustained, selective, switching and divided attention.
The tasks used were the same as the treatment originally modified by Dr. Jamie Mayer and colleagues (Mayer et al., 2010). Some parts of the treatment were removed to allow for more detailed treatment in important areas of dysfunction. The treatment was administered to a non-brain-damaged individual for 90 minutes twice per week. The treatment schedule was for 8 weeks as follows: sustained attention was treated during the first week. DC was to maintain attention for a long period of time while responding to stimuli. For the second and third weeks of treatment, the test section was selective attention from the APT-II. This required DC to maintain selective attention on the task to respond to stimuli while ignoring the background noise. The fourth, fifth, and sixth weeks were dedicated to alternating attention. This section allows for practicing skills related to mental flexibility, for example being able to alternate between stating whether a letter comes before or after the preceding letter in a list. During this section, it was required that DC was to switch between writing the letter that comes just before the letter written to just after the letter written. The seventh and eighth weeks were dedicated to divided attention. DC needed to perform two tasks at one time simultaneously. One task was responding concurrently to auditory stimuli and stimuli on a worksheet.
<table>
<thead>
<tr>
<th>Session #</th>
<th>Date</th>
<th>Activity</th>
<th>Comments/Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>9/28/09</td>
<td>RBMT, TONI-3, APT Questionnaire</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>10/2/09</td>
<td>TEA, DKEFS (portions)</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>10/6/09</td>
<td>Baseline 1 WM, 2-back HI, 2-back LO, 2-back Faces</td>
<td></td>
</tr>
</tbody>
</table>

**DC Treatment Schedule**

<table>
<thead>
<tr>
<th>Session #</th>
<th>Date</th>
<th>Activity</th>
<th>Comments/Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>10/17/08</td>
<td>Selective Attention</td>
<td>WM Probe 1</td>
</tr>
<tr>
<td>T2</td>
<td>10/18/09</td>
<td>Selective Attention</td>
<td>WM Probe 2</td>
</tr>
<tr>
<td>T3</td>
<td>10/25/09</td>
<td>Selective Attention</td>
<td>IVB too hard when said slowly</td>
</tr>
<tr>
<td>T4</td>
<td>10/25/09</td>
<td>Selective Attention</td>
<td></td>
</tr>
<tr>
<td>T5</td>
<td>10/28/09</td>
<td>Alternating Attention</td>
<td>III D too difficult to maintain pattern</td>
</tr>
<tr>
<td>T6</td>
<td>10/30/09</td>
<td>Alternating Attention</td>
<td>III D too difficult, has trouble with alphabet order</td>
</tr>
<tr>
<td>T7</td>
<td>11/7/09</td>
<td>Alternating Attention</td>
<td>IVD very difficult, needed to read it out loud</td>
</tr>
<tr>
<td>T8</td>
<td>11/8/09</td>
<td>Alternating Attention</td>
<td>IVD probe 3 IVD still difficult, but required less prompting</td>
</tr>
<tr>
<td>T9</td>
<td>11/9/09</td>
<td>Alternating Attention</td>
<td>WM Probe 4</td>
</tr>
<tr>
<td>T10</td>
<td>11/11/09</td>
<td>Divided Attention</td>
<td>WM Probe 5</td>
</tr>
<tr>
<td>T11</td>
<td>11/29/09</td>
<td>Divided Attention</td>
<td>WM Probe 6</td>
</tr>
</tbody>
</table>

**DC Test Schedule**

<table>
<thead>
<tr>
<th>Session #</th>
<th>Date</th>
<th>Testing</th>
<th>Comments/Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>12/3/09</td>
<td>WM Exposure, 2-back HI, 2-back LO, 2-back Faces</td>
<td>Other tests were within normal limits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DKEFS Color-Word Interference</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Client DC’s treatment schedule was based on the modified APT-II schedule for a client with CADASIL. The baseline tests were completed within the first two weeks of meeting with DC. This included the initial probes of 2-back HI, 2-back LO, and 2-back Faces. The treatment and 2-back HI probes were conducted twice per week for eight weeks. Post-treatment testing was conducted in the last week of meeting with DC.

DC progressed through the modified APT-II program and was able to reach criterion of 80% accuracy two times per task listed. Occasionally DC required the help of task modifications and prompting on some harder tasks. These modifications were similar to that required by client SB (Mayer et al, 2010). Modifications included slower presentation rates and clinician verbalizing the task as needed. The tasks were very difficult sometimes and when the tasks became more difficult, DC experienced great frustration. More practice with harder tasks resulted in DC becoming more comfortable with his skills.
E. Post-treatment Testing

The ninth week of the treatment involved post-treatment testing to assess the progress, if any made by DC in cognitive function. The same pre-treatment testing was used during the post-treatment testing in order to assess this progress. The tests used in the post-treatment testing were the Rivermead Behavioral Memory Test (RBMT-3) (Form B), the Test of Everyday Attention (TEA) (Form B), the Test of Nonverbal Intelligence (TONI-3) (Form B), and the Delis-Kaplan Executive Function System (D-KEFS). The three probes were also given again: 2-back faces, 2-back HI and 2-back LOW. Again, the 2-back LO and 2-back Faces probes were used as exposure controls and thus administered only at baseline and again in post-treatment.
DATA AND RESULTS

All data were collected and results determined by comparing the scores from pre-testing to post-testing. The visual working memory probes (n-back) were compared to determine the post-treatment improvement. Both the probes responses and reaction times of those responses were calculated to see improvement based on accuracy as well as the time it takes to make the correct response.

![Graph showing probe performance changes](image)

**Figure 1.** The graph above shows the changes in probe performance throughout the treatment schedule. Notice the marked improvement in each probe type. 2-back LO frequency and 2-back Neutral Faces probes were only conducted in the baseline tests and post-testing. 2-back HI frequency probes were conducted throughout the treatment nine times before pos-testing was conducted.
Figure 2. This graph refers to the reaction times of the visual working memory probes. Reaction time for all n-back probes decreased over the course of the treatment span. The reaction time for the 2-back HI frequency probe was calculated throughout the therapy and had decreased over time. The probe at T9 was skewed possibly from the client's mood. Visual inspection of these data reveal that generally, reaction time steadily decreased during the treatment. The reaction time for the exposure probes (2-back LO and 2-back Neutral Faces probes) also decreased.
Table 2. This chart shows the improvements of the D-KEFS section, Color-Word Interference. Results of clients DC and SB are both shown for comparative purpose.

<table>
<thead>
<tr>
<th>Subtest</th>
<th>DC</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color-Word Interference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color Naming</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Word Reading</td>
<td>11</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Inhibition</td>
<td>13</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Inhibition/Switching</td>
<td>6</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Completion Times</td>
<td>13</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Inhibition vs. Color Naming Contrast</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Inhibition/Switching vs. Inhibition Contrast</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Subtest SB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color-Word Interference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color Naming</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Word Reading</td>
<td>10</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Inhibition</td>
<td>13</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Inhibition/Switching</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Completion Times</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Inhibition vs. Color Naming Contrast</td>
<td>13</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Inhibition/Switching vs. Inhibition Contrast</td>
<td>4</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

This was the one test on which DC’s performance was below normal limits for his age. This portion of the D-KEFS was given again to determine if there was an improvement in the ability to name colors quickly and switch between saying the color of the word and saying the word. This task was quite difficult for DC the first time. When comparing the Pre- and Post-treatment results the improvements are shown in scaled scores. DC improved in the following sections; word reading, inhibition, inhibition/switching, completion times, inhibition vs. color naming contrast, and inhibition/switching vs. inhibition contrast. He remained the same in the color naming portion. Inhibition/Switching and inhibition/switching vs. inhibition contrast were areas in which DC increased significantly. This section tests the ability to switch between stating the word and naming the color the word is printed in, in the shortest amount of time possible (Delis, 2001). The task was very difficult in the beginning for DC but at the end of treatment it seemed easier.
For SB, he improved in the following sections: inhibition/switching, and inhibition/switching vs. inhibition contrast. He remained the same in the color naming, inhibition, completion times, and inhibition vs. color naming contrast portions. Inhibition/Switching and inhibition switching vs. inhibition contrast were areas in which SB increased significantly.

**DISCUSSION**

The results of pre- and post-treatment test scores and within treatment probes indicated that there was a significant increase in correct responses (Figure 1) and a significant decrease in reaction times (Figure 2). These results tell us that DC was more accurate and responded more quickly to answers by the end of treatment. This improvement also informs us that the treatment has had some effect in the improvement of short term memory function. Figure 2 shows the probes that were given in the baseline testing and post-testing. Reaction times decreased after the treatment. As a result of the reaction times decreasing, the short term memory reactions improved significantly. This could be a direct result of the APT-II treatment schedule given to the client. I believe that practicing these tasks so often, about twice per week, aided DC in his everyday cognitive functioning. He has expressed that he feels more comfortable handling more than one task at a time (i.e. divided attention). Due to the improvements noted, I believe that the APT-II served some function in his ability to attend to many stimuli at the same time. When the improvements were compared to that of an individual with MCI/CADASIL, the modified treatment protocol appears to positively affect memory and attention skills for both individuals.

The treatment protocol for DC was very similar to that of SB. DC seemed to progress more easily throughout the treatment and SB found some difficulty in areas that needed to be made easier. SB’s ability to attend to all of the tasks was slightly impaired.
and it took him a little longer to complete the treatment. This is completely fine because
the treatment can be adjusted to assist the client's needs. DC had difficulty in the
selective attention section where it required him to focus on the reverse spelling of words
or the order of the alphabet. This was due to the fact that he did not have a substantial
about of experience with the alphabet which was the focal point of the tasks. These
tasks were made easier for DC to get through and he is a non-brain-damaged individual.
The ability to succeed in each task depends on the individual but in the end, both DC
and SB finished the treatment program in the time allotted.

Table 2 shows the results of the Color-Word Interference task that DC and SB
both improved on from pre- and post-treatment testing of the D-KEFS. This could be due
to practice and being comfortable with performing the task, or it could have direct
relation with the affect of the treatment on attentional ability. The implication of both
clients improving significantly in the same test is that the APT-II treatment program can
improve cognitive and memory functions in both impaired and non-brain-damaged
individuals. The reliability and validity measures of the D-KEFS were completed for
individual subtests versus the entire battery. This seems to be a more accurate source of
measures. The Color-Word Interference task included reliability data. Internal
consistency was measured for the 60-69 age group and was determined to be 81% for
the combined color naming and word reading composite score. This is a good indicator
of reliability of the test to be consistent across different condition. Test-retest reliability
was also studied and the times to complete the Color-Word tasks increased suggesting
improved performance due to being exposed to the test (Delis et al., 2001). For the age
group 50-89 years, the test-retest correlation is in the 50-60% reliability range (Delis et
al., 2001). “A correlation between .80 and .90, which is a benchmark for many tests used
for educational, clinical, and research purposes, would be considered a very strong
correlation” (Maxwell et al., 2005). These results suggest that as a person ages, the
reliability for test-retest would slowly diminish and become weaker. In the future, more controls will be tested to determine reliability of test-retest in the Color-Word Interference section of D-KEFS (Delis et al., 2001).

Further examination of the results show that the treatment has the potential to work well with someone suffering from MCI or other forms of cognitive impairment that affect everyday memory and attentional skills. Crucially, the results show that the APT program can improve working memory/attention even in individuals who are not suffering from a cognitive impairment. This conclusion supports recent emphasis on “brain training” for non-brain-damaged adults to augment cognitive functioning in aging. Posit Science, for example, claims their program speeds up brain function, improves accuracy, and strengthens long and short term memory (Posit Science, 2010). Further study of long-term maintenance of skills following APT-II training is required. Initial results (Mayer et al., 2010) demonstrate subjective maintenance of treatment effects (i.e., Attention Questionnaire) up to one year post-treatment. Additional testing of non-brain-damaged individuals is needed to support the current conclusions with more evidence.
REFERENCES


