DIGITAL APPLICATION OF MoCA-BASED NEUROSCIENCE

NICHOLAS DOYLE
SPRING 2014

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Computer Science
with honors in Computer Science

Reviewed and approved* by the following:

John Hannan
Associate Professor of Computer Science and Engineering
Thesis Supervisor / Honors Adviser

Jesse Barlow
Professor of Computer Science and Engineering
Faculty Reader

* Signatures are on file in the Schreyer Honors College.
The Montreal Cognitive Assessment (or MoCA) was designed as a test to screen for mild cognitive dysfunction and assesses the following cognitive domains: attention and concentration, executive function, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. This test only takes about ten minutes to complete, but previously the test has only been given as a paper version. The MoCA App is an iOS application specifically designed for digital use with goals of a functional prototype and future testing trials using this prototype. Using Apple software and applications development tools, we developed this application for use in testing via Apple iPad. The app is currently in a functional state but could be extended in many ways to increase both ease of use and further completeness of functionality.
# TABLE OF CONTENTS

List of Figures ............................................................................................................. iii

List of Tables ............................................................................................................... iv

Acknowledgements .................................................................................................... v

Chapter 1 Introduction ............................................................................................... 1
  Problem ..................................................................................................................... 1
  Motivation ............................................................................................................... 2
  Goals ....................................................................................................................... 3
  Approach .................................................................................................................. 3
  Remaining Chapters ............................................................................................... 4

Chapter 2 Background .............................................................................................. 5
  MoCA Summary .................................................................................................... 5
  Current State ......................................................................................................... 5

Chapter 3 Automation ............................................................................................... 8
  Design of User Interface ....................................................................................... 8
  Implementation ..................................................................................................... 9
  Legal Implications ............................................................................................... 10

Chapter 4 MoCA Application .................................................................................. 11

Chapter 5 Final Review ........................................................................................... 28
  Evaluation ............................................................................................................ 28
  Future Development ............................................................................................ 28

Appendix A Original Montreal Cognitive Assessment (paper) test ......................... 31

BIBLIOGRAPHY .................................................................................................... 32
LIST OF FIGURES

Figure 1: MoCA Test Home Screen ................................................................. 10
Figure 2: Starting the MoCA Test ................................................................. 11
Figure 3: Alternating Trail Making ............................................................... 12
Figure 4: Visioconstructional Skills (Cube) .................................................... 13
Figure 5: Visioconstructional Skills (Clock) .................................................... 14
Figure 6: Naming - Animals ........................................................................... 15
Figure 7: Memory Recall ................................................................................ 16
Figure 8: Attention - Forwards and Backwards Digit Span ................................ 17
Figure 9: Vigilance (Tapping) ......................................................................... 18
Figure 10: Serial Subtraction ......................................................................... 19
Figure 11: Sentence Repetition ....................................................................... 20
Figure 12: Verbal Fluency .............................................................................. 21
Figure 13: Abstract Reasoning ........................................................................ 22
Figure 14: Delayed Recall ............................................................................. 23
Figure 15: Orientation Check ......................................................................... 24
Figure 16: Options Page .................................................................................. 25
Figure 17: Review Data ................................................................................... 26
LIST OF TABLES

Table 1: Upcoming MoCA Developments (Nasreddine “MoCA©”) .......................... 7
ACKNOWLEDGEMENTS

I’d like to acknowledge Dr. Nikki Hill for the initial idea for the app, without which I would probably be completing a much less interesting thesis. Her feedback based on her non-coding perspective really helped me to look at everything in a new way and gave me a greatly supportive foil for my ideas and workings.

I’d also like to express my sincere gratitude to my Honors Advisor, Professor John Hannan, for his help in guiding me through both this thesis as well as my last three years with the University. His knowledge of the Honors College and their degree planning was invaluable, and the time he set aside in his schedule to review my current status and future plans was instrumental in the successful completion of this thesis. I appreciate his guidance and advice throughout my career as an undergraduate student.

Finally, I’d like to thank Robert Dick for his contribution to coding and testing during the development of the app. He was a great person to bounce ideas off of and his knowledge of coding meant there was always someone to turn to if I ran into a dead end in the middle of the night. His feedback via iPad testing was also extremely helpful in gaining a non-MoCA-oriented perspective of end-user interactions, even though he hates me for exploding a bag of Uncle Ben’s® Ready Rice in our microwave.
Chapter 1

Introduction

Problem

The Montreal Cognitive Assessment (MoCA) is a well-established brief screening instrument for cognitive dysfunction, which is currently available only in a paper-based format. Adapting this instrument for use on mobile devices would extend opportunities for use of the MoCA in both clinical and research settings, as well as provide for collection of additional data unique to a technology-based format. The main problem that this thesis addresses is that of the Montreal Cognitive Assessment test and its lack of availability in digital form. Dr. Nikki Hill is currently researching Mild Cognitive Impairment (MCI) and was curious about digitizing the currently existing version of the paper MoCA test. The paper test version of the MoCA has shown to be a fairly good indicator when it comes to detecting MCI; in a study involving 94 test subjects, the test had a sensitivity of 90% and a specificity of 87% (Nasreddine et al., 2005). The same study also showed that the test had a sensitivity and specificity of 100% and 87% respectively when used to detect early-onset Alzheimer’s disease with a similarly large sample size of 93 subjects. A digital application form of the MoCA test would take the originally human-administered paper test and create an electronic form that can be administered remotely and evaluated more thoroughly for scoring purposes. This use of technology to make an application that is more readily available to individuals, clinicians, and researchers and exists as a digital application was the main problem that we faced with this project. Other aspects of the problem to consider include how we want the user to be interacting with the digital form and how to design the digital test to be as user-friendly as possible.
Motivation

My interest in application development was probably one of the leading factors that got me involved with this project. An application seemed to be the most logical choice for the project because of its ability to be shared on a mobile platform of our choosing. An app could also offer certain advantages and improvements over the human-administered paper version of the test. One of these improvements is the ability to replay the user’s actions multiple times, whether that is listening to the subject’s verbally dictated responses or watching the paths that they chose in drawing various figures. A human administrator would only hear and see the responses once, which might cause them to miss something, or they might mishear the responses given and ask clarifying questions, thus altering the way that the test is given and possibly skewing the results. The app can also offer a behind-the-scenes timing of each individual stage; having a human administrator use a stopwatch or something similar to time stages and then record them would be distracting to the subject at hand and would probably make them feel more pressured, thus also possibly leading to skewed results. This data-gathering technique could be used to compare hundreds of future trials and detect outliers of the data set in the review of the data. The ability to share and store results in a digital format would also be a help for a research setting.

On a more personal note, my grandfather was diagnosed with Parkinson’s disease (PD) at a late stage in the disease; methods of screening such as the MoCA test might have been able to detect the disease more quickly and although there is currently no existing cure, the symptoms may have mitigated more quickly. Since Parkinson's disease is often idiopathic (i.e. having no known cause), having better and more readily available methods of screening for cognitive impairment would obviously be beneficial for future generations to come.
Goals

Goals for this project included a functional digital prototype of the Montreal Cognitive Assessment test, as well as possibly running testing trials using the prototype version of the application, multiple devices, and volunteers from the University. Although testing trials have not been completed, the possibility still exists in the near future.

Approach

Before getting into the actual coding of the application, we needed to carefully plan out how we wanted to approach the problem with my previously stated goals in mind. My approach to this project involved several major planning steps:

• Reading the App Store Review Guidelines for iOS applications
• Breaking the application down into various stages
• Downloading, installing, and configuring Xcode on a Mac
• Developing the application itself
• Creating a Development Certificate Signing Request
• Registering the test iPads with Apple
• Testing the development application via TestFlightApp

The bulk of the work was contained in the actual development of the application, but none of this would’ve been possible without proper planning. Breaking the app down into various stages involved thinking ahead about how the user’s interactions would be documented, how data would be stored, and multiple design decisions involving user interfaces and interaction, along with many other considerations.
Remaining Chapters

Throughout the remainder of this thesis, I will explain the background of the Montreal Cognitive Assessment test more in-depth as well as its current state, expound on the process through which I automated the MoCA test, consider legal implications that may follow, break down the different stages of the app, and provide a final review evaluation of the app with my thoughts on possible future development.
Chapter 2

Background

MoCA Summary

The Montreal Cognitive Assessment (or MoCA) was a test created in 1996 to screen for mild cognitive impairment. The test was named as such because Dr. Ziad Nasreddine created it in Montreal, Canada. It is a full page in length and can be administered in approximately 10 minutes. The test consists of one full page of questions addressing several different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation.

Current State

The current test has several separate stages that are grouped into cognitive domains. Attention, concentration, and working memory tasks involve a detection test, repeating digits forwards and backwards, and serial subtraction (6 total points). Short-term memory is evaluated using a pair of learning trials of five nouns and then a delayed recall approximately five minutes later (5 points). Executive functions are gauged using alternating trail making, vocabulary fluency, and abstract reasoning tests (4 total points). Language skills are evaluated via an animal-naming test, repetition of two complex sentences, and the fluency test mentioned above (5 total points). Visuospatial skills are measured using a clock-drawing task and copying a three-dimensional cube copy (4 total points). The last thing to be evaluated is temporal and special orientation (6 points) for a total of 30 points. A point is
added if the subject has an education level below 12 years of formal schooling. Scoring less than a 26 on the current test is considered abnormal.

As of 2 April 2013, the MoCA test is available in 36 different languages or dialects. It has a couple different alternate forms for the English and German versions designed for studies over time, and the MoCA application is based on the first and most commonly used English version of the test. The MoCA is currently being used to detect Mild Cognitive Impairment in multiple different conditions, including Alzheimer's disease, Multiple Sclerosis, Vascular Cognitive Impairment, Parkinson’s disease, REM sleep disorders, HIV, Fronto-temporal dementia, Huntington’s disease, heart failure, lung disease, sleep apnea, substance abuse, visual impairment, brain tumors, lupus, and epilepsy (Carolan Doerflinger, Boltz, and Greenberg). According to the MoCA© News webpage, the Validation Study article published in 2005 was cited by 1269 peer-reviewed journal articles and 1874 total articles overall (Nasreddine).

The MoCA’s main competitor in the realm of cognitive function in mildly impaired individuals is the mini–mental state examination (MMSE). The MMSE has been very commonly used in dementia research, but research shows that it is relatively insensitive and variable when administered to mildly impaired individuals (Gever). In Gever’s article, Henry Paulson, MD, of the University of Michigan stated, “The MMSE is a tried and true measure, quickly administered [and] it's good for memory but a little bit deficient on executive dysfunction.” He explained further that the MoCA “has the same short time frame, a little more in the executive realm -- so it captures one aspect of cognitive dysfunction that exists in many patients.” Clearly both the MMSE and the MoCA have their own strengths and weaknesses: the MoCA has a slightly better diagnostic accuracy than the MMSE and has been demonstrated to be the more sensitive tool (Nasreddine et al., 2005).

As seen in the table on the next page, the MoCA test also has many different alternate versions that are currently undergoing modifications or still undergoing development. The site mentions a
“MoCA-App for tablet/smartphone users” but doesn’t go into any more details, so details of this
including targeted platforms and devices are currently unknown.

Table 1: Upcoming MoCA Developments (Nasreddine “MoCA©”)

<table>
<thead>
<tr>
<th>MoCA-MIS</th>
<th>To assess the usefulness of the Montreal Cognitive Assessment Memory Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoCA-ACE</td>
<td>To obtain normative data for Age (18-99 years), Culture (10 languages), and Education (3-</td>
</tr>
<tr>
<td></td>
<td>15 and more years)</td>
</tr>
<tr>
<td>MoCA-Drive</td>
<td>To assess MoCA's ability to predict success or failure on a road test</td>
</tr>
<tr>
<td>MoCA-Alternate</td>
<td>To develop parallel versions of the test to decrease possible learning effects when the test</td>
</tr>
<tr>
<td></td>
<td>is frequently administered</td>
</tr>
<tr>
<td>MoCA-Basic</td>
<td>To develop a MoCA version for illiterate and less educated subjects</td>
</tr>
<tr>
<td>Mini-MoCA</td>
<td>To develop a short 5 minute version of the MoCA</td>
</tr>
<tr>
<td>MoCA-ADL</td>
<td>To correlate cognition domains on the MoCA with everyday function</td>
</tr>
<tr>
<td>MoCA-App</td>
<td>For Tablet/Smart Phones users</td>
</tr>
<tr>
<td>MoCA-Certification</td>
<td>An online program to help improve standardized administration and interpretation</td>
</tr>
</tbody>
</table>
Chapter 3

Automation

The automation of the MoCA test as an iPad application involved several different considerations, including how the user would interact with the application, designing the user interface to be user-friendly, implementing the actual application using 3rd-party software, and thinking about any legal implications that may come with the use of such an application.

Design of User Interface

Thinking about how the user would interact with the application was a very important part of the process. One of the most important considerations for building this app was how the target audience would view the app. Obviously the policy that “general accessibility and usability guidelines are good enough” doesn’t really apply in this case. With the consideration that the subjects would be affected by MCI, it follows that a good design strategy would be along the lines of “less is more.” With that in mind, here are some of the design decisions that we focused on:

Minimalist Design: The design for each screen focuses on the instructions and the main screen, with clear, concise instructions, and consistent, readable fonts. The interfaces are uncomplicated and uncluttered, and style is kept consistent across all screens.

Soft Colors: We chose mostly pastel colors to make it easy on the eyes while still denoting the change between screens in combination with animations so that it is clear to the user that he or she has moved to a different stage.

Large Text: Providing the user with concise instructions gave us the digital “real estate” to use larger fonts, helping to aid in app usability and reduce difficulty for the user.
**Straightforward Navigation:** There are a limited number of stimuli per stage and each screen has a “Next” button positioned in the same location at the bottom of the screen (refer to Chapter 4: MoCA Application for more details) to advance the subject to the next stage.

**Implementation**

The application implementation involved several stages of coding, but a couple stages stood out in particular. One of those was the problem of data storage. Currently, all data is stored inside a Model class. Most of the data are stored in some type of NSString (or text-based) variables, and represented to the viewer as such. Times for each stage are tracked very simply: a timer is started at the beginning of each stage, then invalidated and saved in the Model in association with that stage.

One of the featured improvements of the MoCA application over the paper version of the test is the ability to replay various actions of the user. For future audio inputs, this will be as simple as playing the sound clip again. However, replaying the path that the user took to draw a figure was a bit more complicated. The UIBezierPath class is provided by Apple and was used at the suggestion of Professor Hannan. Apple’s documentation defines it as “[a] class lets you define a path consisting of straight and curved line segments and render that path in your custom views.” Initially, the path was simply saved and then shown on the screen during data review. This UIBezierPath class was extended to make a custom NMDBezierPath class and added a time lapse in to keep track of time during the drawing of the path. Essentially, points on the path are associated with times and then the animation process draws the path again, point by point, to show the progression of the drawing in real time.

The main use of the previously-mentioned class is to replay the drawings of the subject taking the test. The most satisfying part of the project was making the extensions of UIView, namely NMDSketchView and NMDReplayView that use the NMDBezierPath class. Both serve different purpose with user interactions, but function together to facilitate the test. The NMDSketchView class is
used to gather input from the user in the form of finger- or stylus-based drawings using the iPad screen and passes it on to the Model for later use. The NMDReplayView uses the data gathered from the corresponding NMDSketchView class and then uses that to effectively “replay” the user’s drawings as they happened. This will aid the scorers in determining how drawings were made and how much time elapsed before possible errors were corrected, which is a major point of the visuoconstructional section of the test.

**Legal Implications**

If this application is to be used in a lab or experimental setting (possibly to vie for an awarded grant or other monetary assistance,) the full realm of legality must be explored as well. One of the most important legal implications that is involved in a study using applications such as this is that of audio recording. Recording people speaking when they don’t know they’re being recorded could have various legal ramifications, so the subject(s) involved in testing should be notified ahead of time, possibly sign a waver, and be made aware that they are being recorded at appropriate stages. Additionally, we might be able to have a doctor administer the test, in which case the doctor’s liability might cover any necessary documentation.

Depending on the current legal state of the MoCA test, we may need to contact the developer of the paper test, Dr. Ziad S. Nasreddine, and making sure it is acceptable to him that we use our digital version of the test. We might also have to cite the article where his team introduces and describes the instrument as well, but that remains to be seen. In addition, the app itself does not store any personally identifying data except for the Subject ID, and the only person that would have the corresponding subject info to go with those Subject IDs would be the PI. As far as we know, those records are kept in a locked cabinet that only the PI can access and are destroyed after the testing is completed, so that shouldn’t be an issue either.
Chapter 4

MoCA Application

A complete overview of all stages of the app is as follows; please refer to Appendix A to compare individual stages to their paper counterparts. The main screen for the application (Figure 1, below) contains an informative label about the name of the test, the current version of the app itself, and buttons to either begin the test or to view options for the application.

Figure 1: MoCA Test Home Screen
If the user chooses to begin the test, they will be shown a UIAlertView (Figure 2, below) for them to input a Subject Number for study tracking and anonymity purposes. If the user chooses to start the test and inputs their proper Subject ID, the test begins. Subject ID validation will be done behind the scenes and involve either the administrator setting a valid range or adding individual subjects.
The first screen involves tracing letters and numbers with the user’s finger or a stylus in an alternating fashion, starting at 1, moving to A, and then alternating between subsequent letters and numbers.

Figure 3: Alternating Trail Making
The next stage involves the user copying a figure of a cube using his or her finger or a stylus. This drawing is reviewable from the View Data option of the Options screen. Here is my attempt:

![Copy the 3-D figured below](image)

*Figure 4: Visuoconstructional Skills (Cube)*
The next screen of the app is the clock-drawing screen. The user is instructed to draw a clock face with their finger or a stylus, complete with numbers and hands positioned at 11:10. Figure 5 below shows my (poor) attempt at completing this stage using a track pad.

Figure 5: Visuoconstructional Skills (Clock)
Next is the Naming stage, where the subject is shown pictures of three animals, one at a time, and must enter the names of those animals in the text box below the picture.
The next screen is the beginning of the memory recall stage. The user presses start to begin playing the audio, which involves five words that the user must remember for a later stage.

Figure 7: Memory Recall
The next stage is the combined forwards and backwards digit span. The user clicks the “Forwards” button to start listening to the digits and then enters them in the text box below “Forwards,” and likewise for the backwards digit span, except the user inputs the digits in reverse order.

Figure 9: Attention - Forwards and Backwards Digit Span
The next stage is the vigilance (tapping) stage, in which letters are read at the rate of one per second. The user begins the test by tapping “Start” and then taps “Tap Here” when they hear an “A.”

Figure 9: Vigilance (Tapping)
Serial Subtraction is the next stage, in which the user begins at 100 and repeatedly subtracts 7 from each subsequent difference. The subject performs five subtractions total, or goes until they cannot continue.

Figure 10: Serial Subtraction
The sentence repetition screen is next, and the subject clicks on the “Begin” button to start the audio, then types the sentence in the text box below after the audio finishes. The subject does this two times.

Figure 11: Sentence Repetition
The verbal fluency stage is next, and the user has 30 seconds to type as many words that begin with the letter “F” as they can. The subject is automatically moved to the next stage after time is up.
The abstract reasoning stage is next, and the subject must think of how the two items listed are similar, and then enter that reasoning into the text boxes. This will need to be scored by a human proctor.
The delayed recall stage is where the subject enters the words that they heard way back in the initial memory recall screen (see Figure 7) to the best of their ability.

Figure 14: Delayed Recall
Last is the orientation check, which asks the user to supply the current date, month, year, day of the week, current location, and current city to check how aware they are of their current state.

Figure 15: Orientation Check
The options page of the MoCA app currently only has an option to view data from the previous run, but will have additional options added in the future, such as valid Subject IDs.

Figure 16: Options Page
The Review Data screen allows the user to review data from the last run of the MoCA test app. This will also allow the user to review the subject’s drawings in replay mode by clicking in the drawings section.

Figure 17: Review Data
Chapter 5

Final Review

Evaluation

The app itself is currently in a functional alpha stage at the moment. I’m pleased at how the replay feature works for the different sketching stages and think that will be valuable for data analysis purposes. Another improvement of the app over the paper test is that the individual times are tracked over individual stages. This could obviously be done very easily by a test administrator, but would be both tedious and possibly distracting to the subject as well. This can offer insight as to how long the subject spent at each stage and again possibly prove valuable when thoroughly analyzed in the context of a much larger data set in the future.

Future Development

Although the app is currently at a functional state, there are still many possible improvements to the app that can be made. In general, the full name of the test could be added to the home screen, as well as a field to enter in a subject code for multiple trials for different subjects as well as different times for runs. The headers from the paper version of MoCA could be added to each test (for example, “Visuospatial/Executive” at the top of the first two "pages.") The default “Siri” voice may be a bit difficult to understand or hear properly at times, especially with the screen where the subject is asked to repeat sentences. This could be changed to a deeper synthesized male voice or alternately recorded as the sentences are directly spoken, rather than as individual words pieced together by a male contributor, as deeper voices are easier for older adults to hear. Additionally, scoring is not currently tracked, which
leaves the actual scoring to the test instructor. This may be able to be automated somewhat to produce a “predicted score,” but a human evaluator will still have to give an assessment of the score in some way. Finally, all screens do not currently have their exact instructions from the Administration sheet of the MoCA test; these could be added in via text or by additional voice synthesis/recording.

In addition, many of the individual “screens” or stages of the app could be improved in various ways in an ideal scenario:

- The Tracing Letters/Numbers stage (called “Alternating Trail Making” on the Administration and Scoring Instructions Sheet) could have an arrow added to indicate the beginning and ending locations sites as specified on the Administration page, as well as dotted lines/arrows as they appear on the paper form (from 1 to A, and then from A to 2.)

- The Naming stage could be altered to have the user speak the words instead of typing them in for better ease of use. The subject should also not be able to move to the next stage of the test until he or she has gone through all of the animals and attempted each sub-stage.

- The initial Memory Recall stage could use the timings of one word per second, which is specified in the Administration sheet. The instructions for this stage should be given via audio synthesis/recording instead of text. There are also two trials of repeating the words done at this stage in the paper version of the test, so this should repeat. Again, audio responses would be preferred here.

- The Repeating Digits stage could be separated into a forwards stage and a backwards stage. The timing could also be altered to fit the stated timing of one digit per second from the paper test.

- The Serial Subtraction stage could have the ability to respond vocally if possible and should include the exact instructions specified in the administration page.
- The Sentence Repitition stage should ask the subject to respond verbally instead of typing their answer. The sound clip should be recorded and scored later by a human evaluator.

- The Verbal Fluency stage needs to be changed so that the keyboard does not impede the subject from moving to the next stage before the time is up so that the subject is able to proceed to the following stage when he or she is ready to do so.

- The Abstraction stage could be altered to accept audio input and follow the administration instructions.

- The Delayed Recall stage could be altered to use verbal input instead of typing.

- The Orientation stage could give instructions by audio and according to Administration guidelines, as well as allow the subject to respond verbally as well.
Appendix A

Original Montreal Cognitive Assessment (paper) test

---

MONTEAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

- **VISUOSPATIAL / EXECUTIVE**
  - Copy Cube
  - Draw Clock (Ten past eleven 13 mins)

- **NAMING**
  - [ ] Rhinoceros
  - [ ] [ ] [ ] [ ] [ ]

- **MEMORY**
  - Read list of words, subject must repeat them. Do 2 trials, each 7 list trials successful. Do a recall after 8 minutes.
  - 1st trial:
    - [ ] [ ] [ ] [ ] [ ] [ ]
  - 2nd trial:
    - [ ] [ ] [ ] [ ] [ ] [ ]

- **ATTENTION**
  - Read list of digits (1-10 sec.) subject has to repeat them in the forward order
    - [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
  - Read list of letters, subject must tap with his hand at each letter in the order:
  - Serial 7 subtraction starting at 100:
    - [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

- **LANGUAGE**
  - Repeal: I only know that John is the one to help today.
  - The cat always hid under the couch when dogs were in the room.

- **ABSTRACTION**
  - Similarity between e.g. banana - orange - fruit
  - Train - bicycle
  - Watch - ruler

- **DELAYED RECALL**
  - Have subject write:
    - [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

- **ORIENTATION**
  - [ ] Date
  - [ ] Month
  - [ ] Year
  - [ ] Day
  - [ ] Place
  - [ ] City

---

TOTAL: [ ]
BIBLIOGRAPHY


<http://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=1883&context=etd>.


<http://www.medpagetoday.com/MeetingCoverage/ANA/42322>.


ACADEMIC VITA

Nicholas Doyle
309 E. Beaver Ave, Apt 204
State College, PA 16801
nmd5149@psu.edu

__________________________

Education

The Pennsylvania State University (Aug 2010 - May 2014)

Schreyer Honors College

- Studying to complete a Bachelor’s Degree in Computer Science with a Minor in Mathematics
- Dean’s List: Fall 2010 - Fall 2012, Fall 2013

Honors and Awards

Academic Excellence Scholarship (2010 - 2014)

- Awarded by the Schreyer Honors College to all Schreyer Scholars who uphold an overall 3.4 GPA and complete the required 16-18 honors credits per four-semester period, renewable

H. Thomas and Dorothy Willits Hallowell Scholars Endowment (2010 - 2014)

- Awarded by the Engineering Department to Penn State students with superior academic records in engineering disciplines, renewable

Microsoft Imagine Cup Software Design Competition - Team Member (2011 - 2012)

- Software Design Team was chosen to be one of ten nationally-selected teams to compete in the Microsoft Imagine Cup Finals in Seattle, WA

Boy Scout Troop 147 - Rank Award of Eagle Scout (2010)

- Completed a fundraiser for the Philadelphia Ronald McDonald House and a Board of Review to attain the highest award in Scouting
Association Memberships/Activities

Springfield FTK  
State College, PA

Technology Chair  
(Mar 2013 - Mar 2014)

- Participated in chair board meetings and maintained organization website as well as participating in and helping to run various fundraising events throughout the year

Penn State IFC/Panhellenic Dance Marathon  
State College, PA

PASS System Developer  
(Apr 2013 - Apr 2014)

- Worked as a team member to design and build the THON Floor PASS System

Professional Experience

Microsoft Corporation  
Bellevue, WA

SDE Intern, Dynamics CRM  
(May 2013 - Aug 2013)

- Worked as a member of the Online Services Team to develop and test for existing Dynamics products and services
- Worked as a team to design and build new features for an upcoming release of CRM Live

Intel Corporation  
Folsom, CA

IRISE Intern, VPG GSV  
(May 2012 - Aug 2012)

- Worked as a member of the Core Validation Team to provide support for Intel HD Graphics driver validation for current and upcoming products
- Designed and built Monthly Status Report Toolkit to eliminate wasted time and ensure uniformity; the completed application will be shared with the other 5 organizations of GSV

MedImmune LLC.  
Washington, D.C.

Biotechnology Computer Programming Intern  
(May - Aug 2011)

- Built and maintained a database of information from nationwide clinical cancer trials
- Gained industry experience with Perl, PHP, HTML, Javascript/AJAX, and MySQL