5-2020

Autism & Autoimmunity

Clarissa Nelson
Utah State University

AUTISM & AUTOIMMUNITY

by

Clarissa Nelson

Capstone submitted in partial fulfillment of the requirements for graduation with

University Honors

with a major in

Biology

in the Department of Science

Approved:

Capstone Mentor Dr. Thayne Sweeten	**Departmental Honors Advisor** Dr. Brett Adams
N/A **Committee Member** [optional: type name or N/A]	**University Honors Program Director** Dr. Kristine Miller

UTAH STATE UNIVERSITY
Logan, UT

Spring 2020

Abstract

My research was for the Honors Capstone, and consisted of familiarizing myself with the vast amount of research in the fields of autism and autoimmunity and how the two may be connected, then going on to design a new project to help acquire more information where these two fields overlap. The official abstract I have written for this new project goes as follows: Our proposed research project is focused primarily in the fields of autism and autoimmunity, and hopes to uncover more evidence that these two fields are related. We believe that autism is an autoimmune disease, and our project is designed to provide evidence to support this theory. We will use neuroimaging techniques through the use of a PET scanner to determine the autoimmune activation in the brains of both individuals with autism and individuals with no history of autism or any other autoimmune disease. This will allow us to test our hypothesis that individuals with autism will have a greater autoimmune response than controls, therefore providing evidence to the theory that autism is a neurological disorder that leads to immune dysregulation in the brain. We are also interested in whether there is a connection between a biological family history of autoimmune disorders and an increased incidence of a diagnosis of autism in individuals. To test this theory, we have prepared a questionnaire meant to identify any and all cases of medical disorders of any biological relatives of the individual in question, to be given to all participants in this study. Information gathered from this survey can provide evidence either for or against our hypothesis, allowing us to determine whether this hypothesis is likely or not. The long-term objectives of this project are to provide more evidence for the theory that autism is an autoimmune disease, and to provide more information on how autism causes immune dysregulation in the brain, thus allowing for better innovation for treatments in the future. Autism is a highly studied disorder, as there still remains much that we do not know, so this study wants to contribute to the knowledge base we have on autism. We hope that by providing evidence that autism is an autoimmune disorder, individuals both within and outside of the health field will be better able to understand individual cases of autism, both in regards to treatment and management of symptoms, and in interpersonal relationships of individuals with autism.

Acknowledgements

I would like to thank Thayne Sweeten for all of his advice throughout my whole project. Without your support I would not have been able to submit such a thorough capstone, and likely would still be trying to develop proposals for this project. Thank you so much for your constant support!!

I would also like to thank Brett Adams, who also helped to guide me throughout this process.

And of course, I would like to thank my mom, for always being there for me when I needed her. :)

Form Approved Through 02/28/2023 OMB No. 0925-0001

Department of Health and Human Services
Public Health Services

Grant Application

Do not exceed character length restrictions indicated.

LEAVE BLANK—FOR PHS USE ONLY.

Type	Activity	Number
Review Group		Formerly
Council/Board (Month, Year)		Date Received

1. TITLE OF PROJECT *(Do not exceed 81 characters, including spaces and punctuation.)*
Autism and Autoimmunity

2. RESPONSE TO SPECIFIC REQUEST FOR APPLICATIONS OR PROGRAM ANNOUNCEMENT OR SOLICITATION ■ NO ☐ YES
(If "Yes," state number and title)
Number: Title:

3. PROGRAM DIRECTOR/PRINCIPAL INVESTIGATOR

3a. NAME (Last, first, middle)	3b. DEGREE(S)	3h. eRA Commons User Name
Nelson, Clarissa Nicole	BS Biology	

3c. POSITION TITLE
Researcher

3d. MAILING ADDRESS *(Street, city, state, zip code)*
1857 W 75 S Kaysville UT 84037

3e. DEPARTMENT, SERVICE, LABORATORY, OR EQUIVALENT
Biology

3f. MAJOR SUBDIVISION
Human Biology

3g. TELEPHONE AND FAX *(Area code, number and extension)*
TEL: (425) 429-1620 FAX:

E-MAIL ADDRESS:
clarissanicole@gmail.com

4. HUMAN SUBJECTS RESEARCH	4a. Research Exempt	If "Yes," Exemption No.
☐ No ■ Yes	■ No ☐ Yes	

4b. Federal-Wide Assurance No.	4c. Clinical Trial	4d. NIH-defined Phase III Clinical Trial
	■ No ☐ Yes	■ No ☐ Yes

5. VERTEBRATE ANIMALS ■ No ☐ Yes — 5a. Animal Welfare Assurance No.

6. DATES OF PROPOSED PERIOD OF SUPPORT *(month, day, year—MM/DD/YY)*		7. COSTS REQUESTED FOR INITIAL BUDGET PERIOD		8. COSTS REQUESTED FOR PROPOSED PERIOD OF SUPPORT	
From	Through	7a. Direct Costs ($)	7b. Total Costs ($)	8a. Direct Costs ($)	8b. Total Costs ($)
09/01/20	05/01/21	50000	50000	50000	50000

9. APPLICANT ORGANIZATION
Name Utah State University
Address Old Main Hill Logan, UT 84322

10. TYPE OF ORGANIZATION
Public: → ☐ Federal ☐ State ☐ Local
Private: → ■ Private Nonprofit
For-profit: → ☐ General ☐ Small Business
☐ Woman-owned ☐ Socially and Economically Disadvantaged

11. ENTITY IDENTIFICATION NUMBER
DUNS NO. Cong. District

12. ADMINISTRATIVE OFFICIAL TO BE NOTIFIED IF AWARD IS MADE	13. OFFICIAL SIGNING FOR APPLICANT ORGANIZATION
Name	Name
Title	Title
Address	Address
Tel: FAX:	Tel: FAX:
E-Mail:	E-Mail:

14. APPLICANT ORGANIZATION CERTIFICATION AND ACCEPTANCE: I certify that the statements herein are true, complete and accurate to the best of my knowledge, and accept the obligation to comply with Public Health Services terms and conditions if a grant is awarded as a result of this application. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties.	SIGNATURE OF OFFICIAL NAMED IN 13. *(In ink. "Per" signature not acceptable.)*	DATE

Program Director/Principal Investigator (Last, First, Middle): Nelson, Clarissa Nicole

PROJECT SUMMARY (See instructions):

Our proposed research project is focused primarily in the fields of autism and autoimmunity, and hopes to uncover more evidence that these two fields are related. We believe that autism is an autoimmune disease, and our project is designed to provide evidence to support this theory. We will use neuroimaging techniques through the use of a PET scanner to determine the autoimmune activation in the brains of both individuals with autism and individuals with no history of autism or any other autoimmune disease. This will allow us to test our hypothesis that individuals with autism will have a greater autoimmune response than controls, therefore providing evidence to the theory that autism is a neurological disorder that leads to immune dysregulation in the brain. We are also interested in whether there is a connection between a biological family history of autoimmune disorders and an increased incidence of a diagnosis of autism in individuals. To test this theory, we have prepared a questionnaire meant to identify any and all cases of medical disorders of any biological relatives of the individual in question, to be given to all participants in this study. Information gathered from this survey can provide evidence either for or against our hypothesis, allowing us to determine whether this hypothesis is likely or not. The long-term objectives of this project are to provide more evidence for the theory that autism is an autoimmune disease, and to provide more information on how autism causes immune dysregulation in the brain, thus allowing for better innovation for treatments in the future. Autism is a highly studied disorder, as there still remains much that we do not know, so this study wants to contribute to the knowledge base we have on autism. We hope that by providing evidence that autism is an autoimmune disorder, individuals both within and outside of the health field will be better able to understand individual cases of autism, both in regards to treatment and management of symptoms, and in interpersonal relationships of individuals with autism.

RELEVANCE (See instructions):

This research is relevant, as by providing more information about the neurological dysregulation that occurs in the brains of individuals with autism we can have a better understanding of autism. A better understanding of how autism works in the brain can also allow for better treatments to be designed, as more specific treatments can be innovated. Should we find evidence that there is a link between prevalence of autoimmune diseases in biological relatives, then individuals wishing to start their families can be more aware of the risk of having a child with autism dependant on their family medical history

PROJECT/PERFORMANCE SITE(S) (if additional space is needed, use Project/Performance Site Format Page)

Project/Performance Site Primary Location		
Organizational Name: Utah State University		
DUNS:		
Street 1: Old Main Hill	Street 2:	
City: Logan	County:	State: UT
Province:	Country: USA	Zip/Postal Code: 84322
Project/Performance Site Congressional Districts:		

Additional Project/Performance Site Location		
Organizational Name: Intermountain Health Care		
DUNS:		
Street 1: 1350 N 500 E	Street 2:	
City: Logan	County:	State: Utah
Province:	Country: USA	Zip/Postal Code: 84341
Project/Performance Site Congressional Districts:		

Program Director/Principal Investigator (Last, First, Middle): Nelson, Clarissa Nicole

SENIOR/KEY PERSONNEL. See instructions. *Use continuation pages as needed* to provide the required information in the format shown below. Start with Program Director(s)/Principal Investigator(s). List all other senior/key personnel in alphabetical order, last name first.

Name	eRA Commons User Name	Organization	Role on Project
Doe, Jane		USU	Imaginary Support
Joe, Billy Bob		USU	Imaginary Support
Rilnam, Notta		USU	Imaginary Support

OTHER SIGNIFICANT CONTRIBUTORS

Name	Organization	Role on Project

Human Embryonic Stem Cells ☒ **No** ☐ **Yes**

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: https://grants.nih.gov/stem_cells/registry/current.htm. *Use continuation pages as needed.*

If a specific line cannot be referenced at this time, include a statement that one from the Registry will be used.

Cell Line

The name of the program director/principal investigator must be provided at the top of each printed page and each continuation page.

RESEARCH GRANT
TABLE OF CONTENTS

* Follow the page limits for these sections indicated in the application instructions, unless the Funding Opportunity Announcement specifies otherwise.

DETAILED BUDGET FOR INITIAL BUDGET PERIOD DIRECT COSTS ONLY	FROM 09/01/20	THROUGH 05/01/21

List PERSONNEL *(Applicant organization only)*
Use Cal, Acad, or Summer to Enter Months Devoted to Project
Enter Dollar Amounts Requested *(omit cents)* for Salary Requested and Fringe Benefits

NAME	ROLE ON PROJECT	Cal. Mnths	Acad. Mnths	Summer Mnths	INST.BASE SALARY	SALARY REQUESTED	FRINGE BENEFITS	TOTAL
Clarissa Nelson	PD/PI		9			10000	4550	14550
Jane Doe			9			0	0	0
Billy Joe			9			0	0	0
Notta Rilnam			9			0	0	0
								0
								0
SUBTOTALS →						10000	4550	14550

CONSULTANT COSTS Radiologist, PET Scanner Technician	8000
EQUIPMENT *(Itemize)*	
SUPPLIES *(Itemize by category)* Medical and Office Supplies	5000
TRAVEL Gas Expenses	500
INPATIENT CARE COSTS	
OUTPATIENT CARE COSTS PET Scanner	30000
ALTERATIONS AND RENOVATIONS *(Itemize by category)*	
OTHER EXPENSES *(Itemize by category)* Compensation to Participants	1500

CONSORTIUM/CONTRACTUAL COSTS	DIRECT COSTS	
SUBTOTAL DIRECT COSTS FOR INITIAL BUDGET PERIOD *(Item 7a, Face Page)*		**$** 59550
CONSORTIUM/CONTRACTUAL COSTS	FACILITIES AND ADMINISTRATIVE COSTS	26797
TOTAL DIRECT COSTS FOR INITIAL BUDGET PERIOD		**$** 86347

BUDGET FOR ENTIRE PROPOSED PROJECT PERIOD
DIRECT COSTS ONLY

BUDGET CATEGORY TOTALS	INITIAL BUDGET PERIOD *(from Form Page 4)*	2nd ADDITIONAL YEAR OF SUPPORT REQUESTED	3rd ADDITIONAL YEAR OF SUPPORT REQUESTED	4th ADDITIONAL YEAR OF SUPPORT REQUESTED	5th ADDITIONAL YEAR OF SUPPORT REQUESTED
PERSONNEL: *Salary and fringe benefits. Applicant organization only.*	14550	14986	15435	15898	16374
CONSULTANT COSTS	8000	8240	8487	8741	9003
EQUIPMENT					
SUPPLIES	5000	5150	5304	5463	5626
TRAVEL	500	515	530	545	560
INPATIENT CARE COSTS					
OUTPATIENT CARE COSTS	30000	30900	31827	32781	33765
ALTERATIONS AND RENOVATIONS					
OTHER EXPENSES	1500	1545	1591	1638	1687
DIRECT CONSORTIUM/ CONTRACTUAL COSTS					
SUBTOTAL DIRECT COSTS *(Sum = Item 8a, Face Page)*	59550	61336	63174	65066	67015
F&A CONSORTIUM/ CONTRACTUAL COSTS	26797	27907	29060	30255	31497
TOTAL DIRECT COSTS	86347	89243	92234	95321	98512

TOTAL DIRECT COSTS FOR ENTIRE PROPOSED PROJECT PERIOD	**$** 461657

JUSTIFICATION. Follow the budget justification instructions exactly. Use continuation pages as needed.

Personnel costs consist of only $10,000 to compensate Clarissa Nelson for her time working on this project. While Doe, Joe, and Rilnam will be working on this project for the same amount of time as Nelson, they have not requested a salary for their time as they do not actually exist. Consultant costs are necessary to compensate the experienced radiologist we will be working with for their dedicated time and effort on this project. We also wish to compensate the technicians who will be operating the PET scanner throughout this project. The PET scanner is a large part of our study, and thus cannot be substituted out for a different machine or such. However, as we do not need to purchase a new machine, we can collaborate with a local hospital and utilize their equipment, compensating them for the cost of each scan we perform using the PET scanner. Travel costs will likely be low, as most of the travel will be moving locally in Logan UT. However, compensation for the amount of gas used in traveling to and from the Intermountain Hospital and the campus of USU would be greatly appreciated. Other expenses would come in the form of compensation to participants in this study. We recognize that we are asking more from our subjects than other studies, and as an incentive to participate in this study we wish to provide a reward to these individuals who do participate upon completion of their part in this study. Payment to subjects is meant to compensate for travel expenses and time.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Nelson, Clarissa Nicole

eRA COMMONS USER NAME (credential, e.g., agency login): CN12908

POSITION TITLE: Researcher

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Utah State University, Logan	B.S.	05/2020	Biology

A. Personal Statement

I have the motivation, training, and expertise necessary to successfully carry out our proposed research project. I have recently completed my bachelor's degree in human biology, with secondary studies in chemistry and psychology, all areas of study related to the fields that will be covered in this research. I have completed plenty of research in my undergraduate studies and have written numerous papers on the results of these studies. Throughout my time at USU, I have learned the importance of working with others and collaborating in order to both complete and present a solid research project to an audience. I have played many roles in these group settings, as both a worker and a leader, and I will use these experiences to help guide me throughout this project in order to effectively complete this research.

B. Positions and Honors

Positions and Employment

2017-20 Researcher, Utah State University, Logan, UT

Other Experience and Professional Memberships

2015-17 Leadership Committee, Key Club, A Service Oriented Club
2017-20 Member, PreMed Club
2017-20 Member, Honors Program

Honors

2017-20 Member of the Honors Program in Good Standing, Utah State University, Logan, UT

C. Contributions to Science

My previous research has usually followed closely set parameters and was guided with the help of various professors at Utah State University. I have had the opportunity to study a variety of different subjects, from the effects of UV light on the survival rates of seed beetles, to the effects of loneliness on the mental and physical

health of individuals of various ages, to NIH-governed guidelines on the regulation of public lands. I have had a wide experience in the field of research, and thus have picked up many skills to aid me as I navigate through a new research project. Each of these projects has resulted in some written product, which would later be presented to some sort of audience that varied in size due to the type of venue.

D. Additional Information: Research Support and/or Scholastic Performance

I have supported various research projects, as previously mentioned, for differing amounts of time ranging from a month to up to a year. These projects all occurred while I was pursuing my own education in efforts to complete my Bachelor of Science degree. I have remained in good standing for most of my time at Utah State University and have remained devoted to my studies in order to do the best I can in each of my classes, and my grades have reflected these efforts.

Program Director/Principal Investigator (Last, First, Middle):

CHECKLIST

TYPE OF APPLICATION *(Check all that apply.)*

☒ NEW application. *(This application is being submitted to the PHS for the first time.)*

☐ RESUBMISSION of application number:
(This application replaces a prior unfunded version of a new, renewal, or revision application.)

☐ RENEWAL of grant number:
(This application is to extend a funded grant beyond its current project period.)

☐ REVISION to grant number:
(This application is for additional funds to supplement a currently funded grant.)

☐ CHANGE of program director/principal investigator.

Name of former program director/principal investigator:

☐ CHANGE of Grantee Institution. Name of former institution:

☐ FOREIGN application ☐ Domestic Grant with foreign involvement List Country(ies) Involved:

INVENTIONS AND PATENTS *(Renewal appl. only)* ☐ No ☐ Yes

If "Yes," ☐ Previously reported ☐ Not previously reported

1. PROGRAM INCOME ***(See instructions.)***
All applications must indicate whether program income is anticipated during the period(s) for which grant support is request. If program income is anticipated, use the format below to reflect the amount and source(s).

Budget Period	Anticipated Amount	Source(s)

2. ASSURANCES/CERTIFICATIONS ***(See instructions.)***
In signing the application Face Page, the authorized organizational representative agrees to comply with the policies, assurances and/or certifications listed in the application instructions when applicable. Descriptions of individual assurances/certifications are provided in the NIH Grants Policy Statement, Section 4: Public Policy Requirements, Objectives and Other Appropriation Mandates. If unable to certify compliance, where applicable, provide an explanation and place it after this page.

3. FACILITIES AND ADMINSTRATIVE COSTS (F&A)/ INDIRECT COSTS. See specific instructions.

☐ HHS Agreement dated: ☐ No Facilities And Administrative Costs Requested.

☐ HHS Agreement being negotiated with Regional Office.

☐ No HHS Agreement, but rate established with Date

CALCULATION* *(The entire grant application, including the Checklist, will be reproduced and provided to peer reviewers as confidential information.)*

a. Initial budget period:	Amount of base $	59,550.00	x Rate applied	45.00%	% = F&A costs	$	26,797.50
b. 02 year	Amount of base $	61,336.00	x Rate applied	45.50%	% = F&A costs	$	27,907.88
c. 03 year	Amount of base $	63,174.00	x Rate applied	46.00%	% = F&A costs	$	29,060.04
d. 04 year	Amount of base $	65,066.00	x Rate applied	46.50%	% = F&A costs	$	30,255.69
e. 05 year	Amount of base $	67,015.00	x Rate applied	47.00%	% = F&A costs	$	31,497.05
			Enter Rate above as a decimal (e.g., 0.25 for 25%, 0.495 for 49.5%)		TOTAL F&A Costs	$	145,518.16

*Check appropriate box(es):

☒ Salary and wages base ☒ Modified total direct cost base ☐ Other base *(Explain)*

☐ Off-site, other special rate, or more than one rate involved *(Explain)*

Explanation *(Attach separate sheet, if necessary.):*
Utah State University requires an overhead cost for all grant requests it receives.

Specific Aims:

This research project aims to test the hypothesis that autism is a neurological disorder associated with immune dysregulation in the brain. This study will also determine if there is a correlation between having a family history of autoimmune diseases and being diagnosed with autism. We will also assess whether there is a correlation between an increased occurrence of familial autoimmune disorders and more immune activation within the brain of an individual diagnosed with ASD.

We expect that the results of this study will yield more information first on whether immune activation in the brain is occurring more often in individuals with autism than controls. Further, we would be interested in seeing where immune activation is occurring within the brain as well as how much activation is occurring in these areas. For the second part of the study, we hypothesize that the results of the survey will reveal that individuals with autism will have a greater incidence of a family history of autoimmune diseases and that having a greater occurrence of autoimmune disease in family history will lead to a greater immune activation in the individual with autism. In the future, we believe that studying individuals with a more severe diagnosis of autism would also be interesting as a case study on whether these individuals have greater immune activation, should we have the time and resources available after completing the other areas of this study.

The results of this study will help test the hypothesis that autism is an autoimmune disorder. Should the results prove individuals with autism have more immune activation in comparison to controls, this evidence would support this hypothesis. Discovering where in the brain immune activation occurs would also go towards explaining more about how the disorder works in individuals with autism, as well as provide more information about how autism could be more easily diagnosed from a neurological standard. There is some potential that in identifying how immune activation occurs and where it arises in the brains of those with autism, we can design better treatments.

Specific Objectives:

- To test our stated hypotheses:
    - Individuals with autism will have a different immune activation in their brains than controls, most likely having a greater immune response than controls.
    - A greater incidence of autoimmune disorders in biological relatives will be correlated with a greater likelihood of autism in individuals.

Research Strategy:

Significance.

This project addresses the hypothesis that autism is an autoimmune disease. We want to better characterize immune contributions to this The importance of our study on autism is that by pursuing more research and information about immune-related functions in individuals with autism we can provide more evidence that will allow us to understand how exactly autism acts on the brain and how this neurological disorder may develop as a result of a dysfunctional immune system. Understanding more about autism will in turn lead the scientific community to innovate new treatments and medications that will be more effective in handling the symptoms of autism, should such a response be necessary. Due to the difference in individual cases, this may not always be the case, hence providing another reason why we are interested in this topic: as individual cases of autism vary, we hope to provide more evidence to the possible causes for this difference in presented symptoms, to determine whether there is a link between severity of symptoms presented in individuals diagnosed with ASD and the amount of presence of autoimmune factors.

Prior research regarding the potential autoimmune component of autism has revealed the importance of the mother's autoantibodies during gestation and development of the fetus as a factor in developing autism. (Braunschweig et al 2012) Plenty of studies describe possible immune factors that may have an effect on the development of autism, each one focusing on certain cells or components that derive from the immune system and appear to be malfunctioning in individuals diagnosed with autism (Careaga et al 2017, DiStasio et al 2019, Suzuki et al 2013).

Studies depicting the use of neuroimaging techniques of immune cells in individuals diagnosed with autism are less frequent. As informational and functional scanning techniques are rather expensive and can be intrusive, it is understandable that such studies are harder to come by than those studying the presence of antibodies in the immune systems of those with autism. There has been limited information on immune related neuroimaging of the brains of individuals with autism. The studies that have been done concerning have used postmortem brains or focused on different autoimmune diseases unrelated as far as we know to autism. However, from the information that has been gathered on other autoimmune diseases using neuroimaging techniques, we know that we can collect a good amount of data by carrying out these studies, which is why our study would be crucial to providing more information on the immune component of autism.

Regarding previous work done on the relevance of a family history on the development of autism, there has been a mixed amount of information found. There is a good amount of research that supports the hypothesis that having a family history of autoimmune diseases leads to an increased risk factor for having a child with autism. (Sweeten et al 2003, Wu et al 2015, Hallmayer et al 2011) One such study described the need for more research to further explain the association between having a family history of autoimmune diseases and an increased risk of autism in children, which is one of the goals of our prospective study (Wu et al 2015). Furthermore, there has been little to no research done exploring a possible correlation between an increased incidence of autoimmune diseases in an individual's family history and an

increased expression of autism symptoms, which is why this will be one of our focuses for this study.

Family history is a newer field that researchers are exploring in relation to diagnoses of autism. There are quite a few studies that have linked a family history of autoimmune diseases with an increased risk of autism in children, though one study done in 2015 stated that more research was needed to further explain the full association between an increased prevalence of AD in biological relatives and the risk of having a child with autism (Wu et al 2015). The general consensus, however, is that there is an increased prevalence of familial autoimmune disease in individuals with autoimmune disorders (Sweeten et al 2003), hence the need for more information to confirm that this is also true specifically for individuals with autism. Our study will be focused on comparing the familial incidence of autoimmune disorders of subjects with autism and subjects with no diagnoses of autism or any other autoimmune disorder.

Previous studies have been done on postmortem brain tissue of subjects with autism, revealing more evidence that ASD brains have an increased activation of immune cells attacking astrocytes near the blood brain barrier (DiStasio 2019). However, this is not a study design that can be repeated easily, unlike studies that utilize neuroimaging. Neuroimaging techniques have potential in determining diagnostic and etiologic information for various autoimmune disorders, and have previously been used in multiple studies. PET scans are especially of interest, as they have potential important diagnostic and etiological importance. Previous studies have shown that PET scanners can provide a reliable method for greater assessment of microglial activations in patients in vivo (Airas 2018). Many studies that have primarily used PET scanners have been focused on various other autoimmune disorders such as multiple sclerosis (Airas et al 2018), and those that have been completed on subjects with autism spectrum disorder are few and far between. Studies that have been completed on individuals with ASD using PET scans have resulted in major discoveries concerning differences between ASD subjects and controls (Zurcher et al 2020), and our study aims to contribute more to these new discoveries. We wish to determine what neurological changes occur in a living autistic brain in order to shed more light on how this disorder works on the brain.

Should the results we expect to see be achieved, we believe that there will be some changes in the fields of autism and autoimmunity. Treatments for autism would likely be able to change for the better, as by understanding the neurological bases of autism, we can better develop treatments that target these specific mechanisms. As for changes in concepts of this field, if we are able to prove there is a higher autoimmune response in the brains of those with autism than those who do not have any diagnosed conditions, we can provide more support for the ongoing theory that autism spectrum disorder is an autoimmune disorder. Preventative interventions that drive the field of autism studies will also be affected by the information we learn in this study if the proposed aims are achieved. If indeed there is a link between prevalence of autoimmune diseases in biological relatives, people wishing to start a family can be more aware of the higher risk of having a child with autism should their family history have a greater incidence of AD.

Innovation.

This application challenges current research and clinical practice paradigms primarily concerning the neuroimaging techniques in conjunction with autism studies. Previous studies have focused on neuroimaging of other autoimmune diseases and on postmortem brains of individuals previously diagnosed with autism. However, to our knowledge there have been few studies done using neuroimaging techniques on living subjects with autism and a control group to compare the results collected from the cases against. Our study will be primarily focused on comparing these two groups and determining the differences between them. We will draw on previous studies that have studied autoimmune components of autism or other autoimmune diseases, by reviewing what techniques did not provide significant results, and refine our own study to avoid those fallacies.

Some of the new concepts we are hoping to introduce with this study are that the severity of autism may be correlated with greater incidence of autoimmune disease in family history. While previous studies have also proposed a possible connection between these two factors, we hope to further this hypothesis by hypothesizing that the severity of symptoms presented in individuals with ASD is correlated to a greater incidence of autoimmune diseases in the individual's near relatives.

A new methodology we are introducing in this study is the use of a PET machine for the use of neuroimaging in relation to autism. In our research, we have not found very many studies that have reported using PET scans with an immune marker to compare brain scans of individuals with autism and individuals with no history of autism or any other autoimmune disease. We have found research describing the use of PET machines to compare the brains of those with autoimmune diseases such as multiple sclerosis, and we will use these studies and the few that have been done on individuals with autism to guide our own study design. Our study differs from these previously mentioned studies in that we are using PET scans of both individuals afflicted with ASD and those who are not, in order to establish a baseline of immune response amongst unaffected individuals to determine the extent of immune activation in individuals with autism.

Approach.

Before beginning our study, we will ensure the complete availability of required materials for this experiment. In order to perform this study, we will need an available and functioning PET scanner and a technician who is experienced with operating the machine. Once prepared, we will go about selecting our sample populations. As this is a pilot study, our sample size will be smaller, also due in part to the fact that PET scans are expensive and will likely take up most of our budget. Ideally, we would have around 15 subjects that have been diagnosed with autism, and 10-15 control subjects that do not have any history with autism that can be used as a match against the subjects with autism. As the control subjects are not the primary focus of the study and are to be used to compare results against, it is not as important to have as many of these subjects as the study group with autism; however that being said it would still be good to have an equal representation to avoid a skewing of data collected.

In collecting our sample, we would aim to find subjects in their adulthood, as adults would be easier to be approved by the IRB, and as neuroinflammation occurs across all ages of ASD (Vargas et al 2004) it would be easier to select older subjects that are more willing to hold still for the imaging process. On that topic, we would likely need to find high functioning ASD

individuals to make up our autism sample group, as they will be more likely to remain still for the duration of the imaging process. Regarding the autoimmune survey, which will be described in more detail later on, having an older sample set also allows for more time for any family members to develop autoimmune diseases, as they tend to occur more frequently with age. Another important factor to consider as we collect our two sample groups is that we find matches for each group. By this we mean that for every subject we find with autism, we want to be able to have a control subject who matches the former subject in age, lifestyle habits, and other important variables that may affect the results of our study.

The collection of our sample will occur through basic advertising and consulting with local medical practices. Informed consent will be obtained. The advertising will take place mainly in the form of posters put up in public areas depicting the need for volunteers for our study and ways to contact us if they are interested. Consulting with local medical practices will also be useful, as it would allow us to seek participants through a certified system, and only if the participants are willing to have their information given out to participate in a study like this. By collaborating with local practices, we place the decision to participate in the study with the individuals and their families, thus preventing any unwilling individuals from participating out of a feeling of obligation or pressure, preventing any potential biased data from being collected in this study. While collecting our sample of subjects with autism, we will have a psychologist evaluate and determine the severity of their symptoms using the Autism Diagnotic Interview-Revised and the Autism Diagnotic Observation Schedule, in order to both determine whether they are high-functioning and thus qualified for the study, as well as for data collection.

Our study will be based locally, within a town or a few neighboring cities in Utah. This decision to keep a smaller range to draw our sample from was made in order to keep confounding factors that arise from being raised in different environments out of our study. By restricting our sample collection to a few close towns, we can ensure that living situations and environmental concerns are as similar as possible to reduce any potential confounding variables. Our decision to base the study in Utah was both due to the fact that there are higher reported rates of autism in Utah than other states in the US, and due to the fact that the researchers are based in Utah and will allow for less travel necessary for the project to be carried out, thus also reducing the travel costs in the budget.

As controls will be based upon the subjects we collect for the autism sample group, we will collect our case group first to determine what kind of control subjects we need to gather. As this study will be focused primarily upon individual data, it is not necessary that all subjects be tested at once; rather this study can be stretched out over the span of a few months to a year if necessary in order to complete the necessary tests and evaluations.

Once both sample groups have been assembled, each participant will be given a survey consisting of questions concerning the presence of autoimmune disorders in any of their relatives, to be completed and returned at a later date to allow time for the collection of accurate data. This survey, attached later in this application, is a questionnaire that has been adapted from a study done by Sweeten et al in 2003, and allows for data to be collected on biological family members related to the individual of interest, their relation to the individual, and any possible medical disorders they may have had. The questionnaire contains detailed instructions for optimal data collection, with examples of what information should be written down, as well as requests to check the data written down with the family member in question. These questionnaires will be given to every subject, regardless of whichever group they were assigned

to, in order to best determine the effect of family diagnoses of other autoimmune disorders on autoimmune response in their PET scans. Should subjects in this study be related at all, each participant will regardless be asked to fill out the survey, in order to ensure consistent data collection. Subjects will send in their completed surveys either on the day they are brought in for their PET scan or at a later date through priority mail to an official office. If surveys have not been sent in by a certain date, we will follow up with the participants and resend the questionnaire should it be needed, and continue to do so until the survey has been completed and submitted.

Subjects in both sample groups will be brought in to a local hospital, where a trained PET technician will perform [^{11}C]PBR28 MR-PET scans on each participant in this study (Zurcher et al 2020). After each subject has gone through a PET scan, we will bring the scans to an experienced radiologist. Each scan will be presented at random, and the identity of the subjects will be hidden from the radiologist, so as to prevent any possible bias on the part of the radiologist when they are determining the amount of immune activation in the brains of these test subjects. The radiologist will pinpoint any areas of high immune expression present in the PET scans, as well as highlight differences between participants, so that we may be able to draw conclusions about whether subjects with autism have a different level of immune expression than control subjects.

Using the data collected from the radiologist, we will then analyze the results using statistical programming to determine if there is a significant difference in the amount of immune activation between cases and controls. Once the surveys have been completed and resubmitted, we will furthermore use statistical programming to determine if there is a significant correlation between a significant family history of autoimmune disease and an increased occurrence of officially diagnosed autism, and the amount of immune expression if we receive positive results in our study.

As with any study, there are always ways potential problems can arise. In this study in particular, one concern we have is that we will be unable to match our subjects in the autism group with accurate matching controls. As this study is dependent on having matching controls in order to determine the true extent of immune activation as a result of autism and not as a result of other factors in the environment, having matching controls is an important part of this study. To avoid this problem, we will look primarily to recruit family members of subjects recruited to the autism group, who have no history of autism symptoms themselves, as they will be more likely to have matching factors such as lifestyle and diet with those in the autism sample. Should matching controls not be immediately available, we will then move on to specifically advertise for a specific type of control that matches the case subject.

Throughout this study there will be plenty of benchmarks for success to allow us to ensure we are making the right progress with this study and to show that things are going well. The first benchmark will be finding willing volunteers with autism to be subjects in our study. This study is dependent on having subjects with autism, so being able to collect enough subjects with autism for our study will be a big success. Another benchmark will be finding controls for each subject with autism, as this will allow us to draw more accurate conclusions as to the real source of any differences in immune activation in the brain. Completing all the necessary PET scans and getting their interpretations will be the next benchmark, as that will be the last of the in-person work that will need to be done with the subjects in this study. Once we have the surveys concerning autoimmune disorders in the subjects' family histories, we will have all the

data we need from our subjects, provided that no mistakes were made and further contact with subjects is unnecessary. Our last benchmark for success will be the completion of all the relevant statistical analysis tests for the determination of significant differences and correlations for our data.

This project is in the early stages of development, so to establish feasibility we will collaborate with other professionals and researchers with previous experience in both research on autism and autoimmune expression. Due to Utah having a higher incidence of autism than other states in the US, there are likely plenty of other researchers locally based that we could meet with and share our study design. These other researchers can thus provide more insight on potential problems with our study that need to be fixed before we continue forward with our project. We can also work with local hospitals and clinics to determine the best times and usage of PET scanners that will be both convenient for study participants and researchers, as well as realistic for the clinic that will be hosting us. We will also present the option that students and residents could help to operate the PET scanner under the supervision of experienced technicians, in order to allow them to gain necessary experience for their own education. Of course, this option will only be available should subjects be willing to have students operate the scanner, and will rely on whether they are comfortable with this idea.

Our research design factors in relevant biological variables through our control group. As our study will rely upon determining significant differences in immune activation between individuals with autism and those without autism, having accurate controls that match the cases collected for the study is very important. Accurate controls will allow us to account for any possible confounding variables, by letting us reduce the likelihood that the immune activation is due to a factor other than autism. Variables such as sex, diet, weight, exercise habits, and plenty of other such biological factors can all be accounted for in this way.

While there are no immediate hazards to life or safety of personnel involved in this study, there is still the potential for problems to arise in this study. Primarily these problems will likely arise during the PET scan portion of this project. As a precaution, subjects will be given a full disclosure before having to go through the procedure, and the option to opt out of the study should they feel too uncomfortable with the procedures. Outside of the PET scanning portion of the study, the greatest hazard to personnel involved in the study is loss of confidentiality.

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RESEARCH & RELATED Other Project Information

OMB Number: 4040-0001
Expiration Date: 10/31/2019

1. Are Human Subjects Involved? ☒ Yes ☐ No

1.a. If YES to Human Subjects

Is the Project Exempt from Federal regulations? ☐ Yes ☒ No

If yes, check appropriate exemption number. ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8

If no, is the IRB review Pending? ☐ Yes ☒ No

IRB Approval Date:

Human Subject Assurance Number:

2. Are Vertebrate Animals Used? ☐ Yes ☒ No

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ☐ Yes ☐ No

IACUC Approval Date:

Animal Welfare Assurance Number:

3. Is proprietary/privileged information included in the application? ☐ Yes ☒ No

4.a. Does this Project Have an Actual or Potential Impact - positive or negative - on the environment? ☐ Yes ☒ No

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ☐ Yes ☐ No

4.d. If yes, please explain:

5. Is the research performance site designated, or eligible to be designated, as a historic place? ☐ Yes ☒ No

5.a. If yes, please explain:

6. Does this project involve activities outside of the United States or partnerships with international collaborators? ☐ Yes ☒ No

6.a. If yes, identify countries:

6.b. Optional Explanation:

7. Project Summary/Abstract Add Attachment | Delete Attachment | View Attachment

8. Project Narrative Add Attachment | Delete Attachment | View Attachment

9. Bibliography & References Cited Add Attachment | Delete Attachment | View Attachment

10. Facilities & Other Resources Add Attachment | Delete Attachment | View Attachment

11. Equipment Add Attachment | Delete Attachment | View Attachment

12. Other Attachments Add Attachments | Delete Attachments | View Attachments

QUESTIONNAIRE DIRECTIONS

1. When filling out this questionnaire, it is important to remember that we want to know how family members are related to the child of interest. Therefore, **write answers in terms of how each family member is related to your child.**

2. We are looking for information only on biological relatives of your child. Therefore, please **do not fill in any information for adopted relatives or relatives by marriage**. We **are** interested in information about first cousins.

> *For example*: Your child's biological uncle may have married a woman with psoriatic arthritis. Although she would be your child's aunt through marriage she would not be a member of your child's **biological** (blood) family. Therefore, she would not be included in the answers. However, the aunt and uncle's children (first cousins) should be included in the answers.

3. If you are unsure about the existence or nature of a specific disease in your family, please feel free to check with family members before mailing the questionnaire back.

4. This study is being done to explore the possible link between certain medical disorders and autism. This questionnaire is not designed to be used by your physician in your treatment. Any questions about the questionnaire or autism should be referred to the principal investigator.

5. In order to fill out the questionnaire correctly, please review the following examples.

EXAMPLES

1) Has anyone in your family been diagnosed with Osteoarthritis (old age arthritis)? _____
If so, how is each person is related to your child?

2) Has anyone in your family been diagnosed with Multiple Sclerosis? _____
If so, how is each person is related to your child?

QUESTIONNAIRE:
Autoimmune Disease in Family Members

List of possible family members for answers.

Mother	Grandfather	Niece
Father	Grandmother	Nephew
Sister	Uncle (biological)	First Cousin
Brother	Aunt (biological)	Other (explain)

1) Has anyone in your family been diagnosed with Osteoarthritis (old age arthritis)? _____
If so, how is each person is related to your child?

2) Has anyone in your family been diagnosed with Rheumatoid Arthritis (onset after age 16)? _____
If so, how is each person is related to your child?

3) Has anyone in your family been diagnosed with Juvenile Rheumatoid Arthritis (onset before age 16)?
_____ If so, how is each person is related to your child?

4) Has anyone in your family been diagnosed with Rheumatic Fever? _____
If so, how is each person is related to your child?

5) Has anyone in your family been diagnosed with Psoriatic Arthritis? _____
If so, how is each person is related to your child?

6) Has anyone in your family been diagnosed with Ankylosing Spondylitis? _____
If so, how is each person is related to your child?

7) Has anyone in your family been diagnosed with Reactive (temporary) Arthritis? _____
If so, how is each person is related to your child?
List of possible family members for answers.

Mother	Grandfather	Niece
Father	Grandmother	Nephew
Sister	Uncle (biological)	First Cousin
Brother	Aunt (biological)	Other (explain)

8) Has anyone in your family been diagnosed with a type of arthritis that is not mentioned previously? _____ If so, please indicate how each person is related to your child **and what type of arthritis they have.**

9) Has anyone in your family been diagnosed with arthritis but you are unsure of the specific type? _____ If so, how is each person is related to your child?

10) Has anyone in your family been diagnosed with Lupus? _____
If so, how is each person is related to your child?

11) If you answered yes to lupus, please tell us what treatment(s) each relative was given. (i.e. kidney transplant, kidney dialysis, steroids, chemotherapy (IV medicine), other (specify), don't know).

12) Has anyone in your family been diagnosed with Dermatomyositis? _____
If so, how is each person is related to your child?

13) Has anyone in your family been diagnosed with Polymyositis? _____
If so, how is each person is related to your child?

14) Has anyone in your family been diagnosed with Psoriasis? _____
If so, how is each person is related to your child?

15) Has anyone in your family been diagnosed with Vitiligo? _____
If so, how is each person is related to your child?

List of possible family members for answers.

Mother	Grandfather	Niece
Father	Grandmother	Nephew
Sister	Uncle (biological)	First Cousin
Brother	Aunt (biological)	Other (explain)

16) Has anyone in your family been diagnosed with Myasthenia Gravis? _____
If so, how is each person is related to your child?

17) Has anyone in your family been diagnosed with Multiple Sclerosis? _____
If so, how is each person is related to your child?

18) Has anyone in your family been diagnosed with ALS (Amyotrophic Lateral Sclerosis, also called Lou Gehrig's Disease)? _____ If so, how is each person is related to your child?

19) Has anyone in your family been diagnosed with Ulcerative Colitis? _____
If so, how is each person is related to your child?

20) Has anyone in your family been diagnosed with Crohn's Disease? _____
If so, how is each person is related to your child?

21) Has anyone in your family been diagnosed with Hyperthyroidism (over active thyroid, also called Graves' Disease)? _____ If so, how is each person is related to your child?

22) Has anyone in your family been diagnosed with Hypothyroidism (under active thyroid, also called Hashimoto's Thyroiditis)? _____ If so, how is each person is related to your child?

23) Has anyone in your family been diagnosed with ITP – Idiopathic Thrombocytopenic Purpura?
If so, how is each person is related to your child?

List of possible family members for answers.

Mother	Grandfather	Niece
Father	Grandmother	Nephew
Sister	Uncle (biological)	First Cousin
Brother	Aunt (biological)	Other (explain)

24) Has anyone in your family had multiple blood clots? _____
If so, how is each person is related to your child?

25) Has anyone in your family had multiple miscarriages (3 or more)? _____
If so, how is each person is related to your child?

26) Has anyone in your family been diagnosed with Scleroderma? _____
If so, how is each person is related to your child?

27) Has anyone in your family been diagnosed with Uveitis (inflammation in the eyes)? _____
If so, how is each person is related to your child?

28) Has anyone in your family been diagnosed with Kawasaki Disease? _____
If so, how is each person is related to your child?

29) Has anyone in your family been diagnosed with Polyarteritis Nodosa? _____
If so, how is each person is related to your child?

30) Has anyone in your family been diagnosed with Wegener's Granulomatosus? _____
If so, how is each person is related to your child?

31) Has anyone in your family been diagnosed with Takayasu's Arteritis? _____
If so, how is each person is related to your child?

List of possible family members for answers.

Mother	Grandfather	Niece

Father	Grandmother	Nephew
Sister	Uncle (biological)	First Cousin
Brother	Aunt (biological)	Other (explain)

32) Has anyone in your family been diagnosed with Vasculitis? _____
If so, how is each person is related to your child?

33) Has anyone in your family been diagnosed with Childhood Onset (type I) Diabetes? _____
If so, how is each person is related to your child?

34) Has anyone in your family been diagnosed with Addison's Disease? _____
If so, how is each person is related to your child?

35) Has anyone in your family been diagnosed with Sjogren's (pronounced: show-grins) Syndrome?
_____ If so, how is each person is related to your child?

36) Has anyone in your family been diagnosed with Pemphigus? _____
If so, how is each person is related to your child?

37) Has anyone in your family been diagnoses with Guillain-Barre (pronounced: gee-ann-baray) Syndrome? _____ If so, how is each person is related to your child?

38) Has anyone in your family been diagnosed with Attention-Deficit-Hyperactivity Disorder (ADHD)?
_____ If so, how is each person is related to your child?

39) Has anyone in your family been diagnosed with Major Depression? _____
If so, how is each person is related to your child?

List of possible family members for answers.

Mother	Grandfather	Niece

Father	Grandmother	Nephew
Sister	Uncle (biological)	First Cousin
Brother	Aunt (biological)	Other (explain)

40) Has anyone in your family been diagnosed with Bipolar Disorder (Manic-Depression)? _____
If so, how is each person is related to your child?

41) Has anyone in your family been diagnosed with Obsessive-Compulsive Disorder (OCD)? _____
If so, how is each person is related to your child?

42) Has anyone in your family been diagnosed with Autism, Asperger's disorder, or another Pervasive Developmental Disorder (PDD)? _____ If so, how is each person is related to your child?

43) Has anyone in your family been diagnosed with Tourette's Disorder? _____
If so, how is each person is related to your child?

44) Has anyone in your family been diagnosed with Schizophrenia? _____
If so, how is each person is related to your child?

45) Were there any family members that you did not have any (or enough) information about in order to answer these questions well? _____ If so, please indicate the **number of these relatives** and how they are related to your child.

Thank you for your participation!

Reflective Writing

Completing my capstone project was an experience I'm not soon to forget. When I started brainstorming what to do for my project, I'll admit I wasn't sure where to begin. I had previously made contact with both Drs. Adams and Sweeten, and started bouncing ideas off of them to help determine what should be the focus of my project. Dr. Sweeten sent me an article called "T-lymphocytes and Cytotoxic Astrocyte Blebs Correlate Across Autism Brains," a new article that described that through the evaluation of post-mortem brain tissue the researchers had discovered that individuals with autism spectrum disorder had dysregulated cellular immunity, resulting in damaged astrocytes in the CSF-brain barrier. This article opened my eyes to a new understanding of autism, as well as introduced me to the concept that autism could be an autoimmune disorder. Previously, I hadn't given much thought to autism, only knowing what I had learned about it in my classes: that autism was a behavioral disorder that was becoming more common. Discovering that there was a common theory that autism could actually be an autoimmune disorder was fascinating to me, especially as I have several family members that are affected by either an autoimmune disease or autism. This new theory combined two topics that are close to home, so to say, and I was excited to learn more about the research that had bone done here.

I started by submitting various proposals to the Honors program for my project, which was my first challenge in this project. After discussing the article with Dr. Sweeten, we had decided that completing a review article could be a worthy project. Unfortunately, I had misunderstood Sweeten while discussing with him and wrote in my proposal that I would like to do an article review, which I later learned was completely different from a review article. After being rejected, I quickly redid my proposal to reflect what I intended the first time around. However, this project was also rejected, for not being quite enough to reflect the amount of work

and effort needed for a capstone project. After more deliberation with my mentors, I resubmitted my proposal, this time proposing that I draft an NIH Research Grant, in which I would design a whole new project on the connections between autism and autoimmunity. In order to complete this grant, I would have to do plenty of research on previous research that had been done in the field of autoimmunity and autism, as well as compile various other components such as a biosketch, a budget, a research design, and a defense of my idea, to name a few. This proposal was accepted, and I quickly went to work, selecting a potential grant I could apply for and delving into the specific requirements.

Some of the challenges I faced came up right away as I started this project. The NIH Grant website had plenty of instructions, which surprisingly was a problem at the beginning. There were various different styles of grants, each with its own specialized instructions. It took some time determining which grant style I would be applying to, and then figuring out which set of instructions I needed to follow. The big challenge here was that the instruction set I was left with was literally hundreds of pages long, so it was somewhat of a struggle trying to determine what exactly I needed to complete. The next struggle was also related, in that the information described plenty of required fillable forms, but gave no way to access them. I tried searching the grant website, clicking on links provided in the booklet, and plenty of other things to try and download these forms, but was met with nothing but undownloadable screenshots and descriptions of how to fill out the forms. At the time I decided to move on to another part of the grant that I could complete without the need of an inaccessible form, but later was able to find a new updated form that merged some of the other forms that I needed, which was a big triumph for me. This new form allowed for a much easier compilation of all the necessary information I needed to include in this grant, and combined some of the forms so I didn't have to fill out multiple individual forms.

Another challenge I had was completing all the research necessary to design my project. At the start of my research, all I knew was that I wanted to design a project that could help provide more evidence backing the theory that autism could be classified as an autoimmune disease. My knowledge about immune systems and immune cells was rather basic, so understanding what some of these sources were describing required some more research on what some of the cells and their functions were, in order to comprehend what these articles meant when they reported that individuals diagnosed with autism spectrum disorder had high or low levels of them compared to controls. All the research I did was meant to help me best understand what was known about the immunity component of autism spectrum disorder, so that when I designed my own project I would be able to best know what had and hadn't worked for other studies in order to draft my own to have the best chance of success.

Determining what my research plan would be was its own challenge, but with a good amount of debate between me and my mentor we were able to narrow down what would be the best project. I had narrowed down all the study types I had seen into a few defined categories, and came up with my own rough ideas for each one. Sweeten and I debated which of these ideas would be most viable for a grant study, and settled on the use of neuroimaging of the brains of individuals with autism, matching them against controls to best determine the true differences, should there be any between the groups. We also discussed adding a second component to this study, which would examine whether there was an association between a greater incidence of autoimmune disorders amongst biological relatives in individuals with a diagnosis of autism than those who did not. Previous studies had started drawing connections between these two factors, and we believed that we could discover more information on this topic. The end goal of this project had the potential to be great: the general goal was that by collecting more information about how autism spectrum disorder impacted immune dysregulation in the brain,

we could have a better understanding of how autism spectrum disorder worked. More broadly however, the information that could potentially be gained on familial history of autoimmune diseases through enacting this study would allow for more knowledge on the likelihood that a child could be born with autism. This project would help people in the community to both better understand the functionality of autism as well as understand the risks and probability of having children who have autism.

I was really grateful for having the chance to complete my capstone project. Autism and autoimmunity are two subjects that I am interested in, and are cross-disciplined between two of my study focuses. With my major in biology and my minor and psychology, I was able to come into this project with some background knowledge, but this project allowed me to expand my thinking and learn more about these two subjects that I enjoy. I admit that there were as many parts of this project that were difficult for me to figure out as there were easy parts, but overall I am proud of what I was able to accomplish in this project with the help of my mentors. To future students beginning their capstones, I offer this advice: Find a subject that interests you, and ask yourself what more you want to know about it. One of my biggest struggles was determining what my project would be about, and it wasn't until I thought about what subjects I wanted to know more about that I was able to figure out what kind of project I wanted to complete. Mentors are a great resource that are there to help you, so utilize their help throughout the whole process of completing your capstone. The honors capstone is a great experience, and helps to represent a culmination of your learning experience here at USU. I wish you all the best of luck!

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Professional Author Bio

Clarissa Nelson is a USU Honors student who graduated with a major in Biology with a concentration on human biology, and minors in Chemistry and Psychology. During her college experience, Clarissa focused mainly on her academic studies, and was a member of the Premed club. She remained in good standing at USU throughout her time there, and participated in various research projects. Clarissa has applied to the University of Utah's PharmD program for Fall 2020 in order to take the next step in the process of becoming a doctor of pharmacy.