Neurochemical Changes Associated with Animal-Assisted Therapy and Implications for Specific Treatment Population: A Literature Review

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Received September 09, 2024
Accepted December 17, 2024
Electronic access December 31, 2024

More than ever, care and research for mental health disorders is crucial to the wellbeing of people across the globe. While there have been many efforts made to come up with options for treatment, there are still many limitations, such as scalability of appropriate care. The main forms of treatment, medication and talk therapy, do not work for everyone as they have their own drawbacks and are not accessible to all. Animal-Assisted Therapy (AAT) presents an opportunity to treat difficult disorders and to reach populations that are typically rendered unable to access care; and yet, research on AAT is relatively new and unexplored. As such, this literature review will review studies on this subject and the methods they incorporate. Provisional findings show that most research on this topic incorporates methods of measurement including surveys, change in neurotransmitter level, changes in blood pressure and heart rate to measure the effects of AAT. Neurotransmitter research emerges as an especially promising and effective way of studying the efficacy of AAT, in supplement with surveys. Therefore, this paper will focus on findings across methods, but especially neurochemical changes that are observed in humans over the course of AAT, and how they provide uniquely improved outcomes for specific populations. The neurotransmitters most relevant to this research are oxytocin, dopamine, endorphins, and cortisol. Many levels of neurotransmitters related to stress decrease, and neurotransmitter levels related to positive emotions go up when interacting with animals, with these results being more pronounced in children with autism. But, there is still much more research that must be done in order to fully understand the potential AAT has to offer as a treatment method.

Keywords: Animal-Assisted Therapy (AAT), Animal Interaction, Neurotransmitter Research, Mental Health Treatment

Introduction

Animal-assisted therapy (AAT) includes the use of animals for treatment to improve patients' cognitive, social, and/or emotional functioning, and can be used as an alternative or supplement to other forms of therapy. AAT may be particularly helpful to those in which medication or talk therapy has not fully aided in improving their mental health symptoms or other general social and emotional issues. Its benefits have been well studied, but its effectiveness does come into question, especially for certain groups. For example, AAT may benefit different populations in unique ways: AAT has been shown to work most effectively for autistic children, meanwhile another study which compared AAT effectiveness in women and men, showed it may be a less successful treatment option for men[1,2]. Since traditional talk therapy and/or medication do not work as psychiatric treatments for everyone, AAT proposes an alternative or supplement to these methods. According to the Center for Disease Control (CDC), 1 in 5 adults in the United States live with a mental illness and over 1 in 5 children ages 13 to 18 are either currently, or have at some point in their life, dealt with a serious mental illness or episode[3]. Despite this, it is estimated that only about half of these people are receiving treatment[4]. With mental health disorders being widespread and chronically undertreated, and people who need treatment unable to access the right care for them, there's an urgent need for studies that explore alternative and understudied psychological interventions such as AAT. This paper will expand on the idea of AAT as an alternative therapy and will explain why furthering research is crucial to the world of psychology and psychological treatments.

AAT comes in many forms, the most popular and well known being the use of therapy animals (usually dogs) and equine therapy. Trained therapy animals can come to hospitals, offices, schools, and counseling offices to provide support for people there. Petting a dog, for example, is a widely accepted way to reduce anxiety, lower heart rate, and bring people a general sense of calmness. These interactions can also help people form social connections without having to talk to other people, which can be beneficial for reducing loneliness and creating social skills5. Equine therapy is mainly used for those with physical disabilities to gain independence by being able to control and take care of a horse, but it can also help neurodivergent individuals build executive functioning and social skills. The motion of riding a horse can be very calming and therapeutic as well as a way to build muscle strength from the sitting position.

There are many potential methods for investigating questions

of AAT efficacy. Studies of animal-assisted therapy have mainly been conducted via surveying or interviewing participants before and after interactions with therapy animals, but there have been some studies that have taken neurotransmitters into account. These studies used blood samples of patients before and after animal interaction to test their levels of specific neurotransmitters such as cortisol, dopamine, oxytocin, and endorphins. There were also many studies that took heart rate and blood pressure into account, and these studies show that interacting with animals causes both to go down[5]. Oxytocin is the most studied of all of these neurotransmitters and it is shown to increase with animal interaction, but because of limited studies and the way the studies were conducted, these results cannot be classified as statistically significant. Many of these studies have participants randomly assigned to control and experimental groups, but the participants themselves were not chosen at random and there are open questions as to the effectiveness of AAT for people who are allergic to certain animals and who have predisposed fears to them due to past traumas[6]. Studies with neurochemical outcome measures may be particularly promising means of addressing AAT efficacy, due to the fact that neurotransmitters are the hormones that make humans feel certain ways, in turn having large results on our behavior. This paper will focus on these neurochemical changes that are observed in humans over the course of animal-assisted therapy, and how they provide uniquely improved outcomes for specific populations.

Results

General health benefits of being around animals

A major theme in the literature, as identified via the planned literature search, was the general health benefits of being around animals. For the entirety of human history, we have seen how the animal-human connection has helped us survive and thrive as a species. From the first domestication of livestock to be raised for food to the domestication of wolves who cleaned up our food scraps and fought predators away from ancient villages, animals have been helping humans for thousands of years. Even today, people reap many benefits of having a pet, such as having to get outside and take it for a walk or having to take responsibility for another member of the household. But, there are many other benefits of animal interactions that anyone can enjoy: lowered heart rate, emotional comfort, increasing social communication, lower stress levels, and giving people a non-human social bond. Having animals also builds executive functioning skills in both children and adults by demanding routine and consistent care, as depicted in Figure 1[7]. Executive functioning are the crucial mental processes that allow the human mind to strategize, focus, prioritize tasks, maintain self-control, and adjust to situation changes. Development of executive functioning skills is critical for healthy childhood development and plays important roles throughout a person's life in school and in work[7].

As shown by this flowchart, when a program or intervention is used, there are many positive results that lead to later improvement in the workplace and career. In this case, AAT would serve as the intervention. These results make sense due to the prior knowledge that animals affect people's mood, decreased stress levels, and social support that are not observed in specific executive functioning studies. With this, it makes sense that in the context of executive functioning, AAT as a treatment would provide the same benefits, with executive functioning explaining how benefits affect people in the future and not just after direct interaction with an animal[7].

Simply touching an animal can lower heart rate and blood pressure which can help decrease symptoms in patients with cardiovascular issues and help them live longer5. For most people, petting an animal will reduce stress levels and increase happiness and quality of life. In psychological treatment, interacting with animals can lower symptoms of anxiety and depression in many patients, and help them build a bond that helps with social interactions[8]. Keeping in mind the abundant benefits animals can have for humans, researchers have been studying methods to assess how animals can help patients with a variety of psychological disorders and neurodivergence, or mental processing/functioning that deviates from the norm (includes those with autism).

Overview of methods for assessing AAT efficacy

Studies done on researching the effectiveness of AAT, have mainly been conducted using surveys, taking heart rate and blood pressure levels, and studying neurotransmitter activity. One study was conducted using the 4-question Patient Health Questionnaire, which is a very brief measurement of anxiety and depression symptoms. The results of this study were a reduction in anxiety, specifically for patients who did not find other treatment methods for their psychological disorders helpful[8].

Heart rate and blood pressure studies are crucial in studying the efficacy of psychological treatments due to their signs for psychological functioning. Despite not being directly connected to the brain, heart rate and blood pressure levels give signs as to the psychological state someone is in. During arousal to a stimulus, the sympathetic nervous system engages, raising heart rate and blood pressure to prepare the body for a quick response to a possible threat. But, when the body is sure no threat is present, the parasympathetic nervous system kicks in to lower heart rate and blood pressure and return the body to homeostasis. AAT is designed to create this parasympathetic nervous system response in order to calm patients who have anxiety or other stresses. There have been many studies that have found AAT highly effective at lowering heart rate and blood pressure. One study found that the heart rates of patients in a hospital setting were significantly higher before AAT treatment

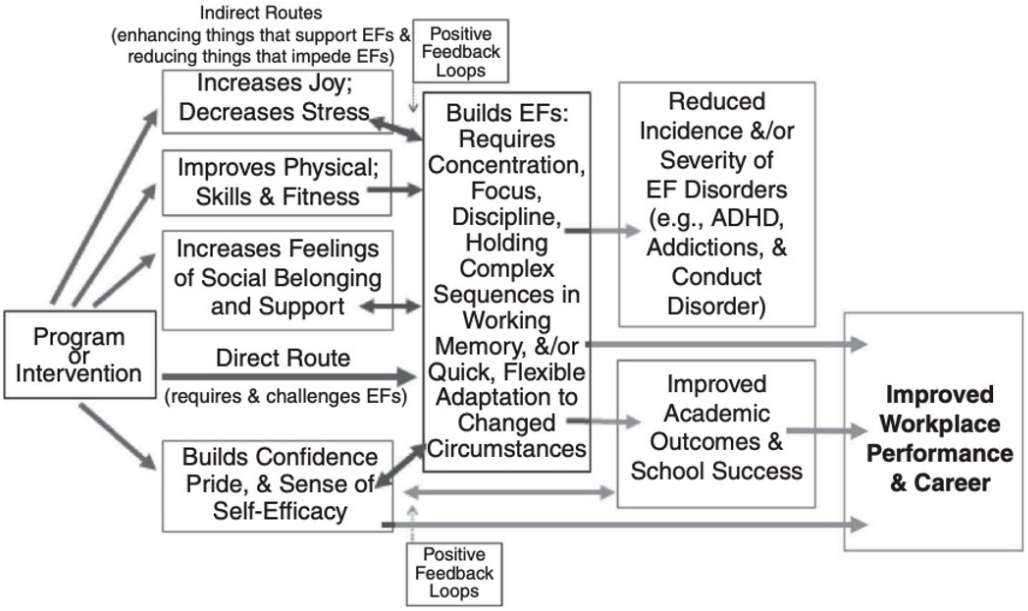

Fig. 1 Flowchart of Executive Functioning

Note. This figure illustrates how activities that directly challenge executive functioning (EFs) skills, have been shown to be most effective in improving these skills and simultaneously reducing obstacles that impair skills use, like stress. Additional outcomes of EF skills use include improved school and workplace performance, as well as reduced incidence of problems related to EF disorders. This shows the benefits animals can have in reduction of EF disorders as the "program or intervention" listed at the start of the flowchart[7].

than after. Particularly the child participants reported feeling relaxed and calmer with an animal present, as well as the animal giving them a motivation to get better[5].

Another biological method of studying the effectiveness of AAT is observing research participants' neurotransmitter levels before and after interacting with an animal. Neurotransmitters are chemicals that are moved from one neuron to the next around the whole body in order to send messages to feel sensations and respond to information that the body receives from the outside world. Neurotransmitters are crucial for many functions of the body, making them an important measure in studying responses to outside stimuli, such as touching or looking at an animal, as done in AAT. There are four main neurotransmitters that appear most often in AAT efficacy studies: oxytocin, dopamine, endorphins, and cortisol. Oxytocin is a neurotransmitter mainly known for its influence on social behavior. Abnormal levels of Oxytocin have been shown to have influences on disorders such as anxiety, schizophrenia, and autism[9]. Dopamine is the brain's "reward" neurotransmitter and plays a crucial role in learning, motivation, and emotion[10]. It gives people a "feel good rush" as a reward for doing something and makes people want to repeat that action. Studies show that lack of dopamine plays a huge role in those with anxiety and depression, meaning that increasing dopamine levels is the main target in anti-anxiety and depression medications. There are multiple types of endorphins, but beta-endorphins are the main kind that influence pleasure and arousal in the brain. Endorphins are the body's natural opiates that also provide good feelings and block pain. They are specifically produced during exercise, but can also be produced when with loved ones or when interacting with something enjoyable[11]. Finally, cortisol is a stress hormone that is involved in a response to physical or emotional stresses[12]. In a research context, levels of these neurotransmitters are often taken from saliva and blood samples, before, after, and sometimes during experimental treatment in order to collect baseline data as well as experimental data.

Neurochemical evidence that AAT works

Few studies have been done testing the neurochemical effects of AAT and those that have been done cannot definitively prove its effectiveness. But each one is a step towards understanding the psychological treatment benefits AAT has and why it is effective. One study using oxytocin levels shows a strong link between the two, as the known release of oxytocin with social interaction and reduction of stress and anxiety goes hand in hand with the same observable benefits of AAT. Through animals' tendencies to provide unconditional love and acceptance, they are shown to be an effective treatment method to provide social connection

and reduce stress levels[13].

There is also evidence that not only do humans reap the positively linked neurotransmitter benefits, but the animals they are interacting with may receive them as well. One study shows the similar positive changes of neurotransmitters like endorphins, oxytocin, and dopamine in both humans and the dogs they were interacting with. This can lead to a strong connection between the human and dogs involved in therapy, causing the positive behavior, mood, and stress changes observed and recorded after interacting with that animal[14]. Perhaps effects like these extend to interactions with other kinds of animals too; however, this study looked only at dogs.

Potential specific benefits for certain populations

Children with Autism

A study was specifically done on measuring the effectiveness of AAT in different contexts: differing age groups, whether or not the participant had autism, the type of animal used, diagnoses the participants had, the location of the treatment, and whether the therapy was conducted as group or individual or in combination. This study is a meta-analysis of many data points and age groups from many other studies, combining the results to create this study. Due to the sheer number of factors being taken into account in this study, many of the results could not be deemed statistically significant, as the results across age groups for these different factors were variable. But, for young children with autism, results across these variables remained consistent; AAT was a very effective treatment form for these children, regardless of other factors. Even for other age groups with autism, the results of the experiment were not as consistent as with the group of 11-year-old and younger. Interestingly, another result of this study was that neurotypical individuals showed more reliable benefits from AAT, particularly in the categories of well-being and behavior. Given this study was a meta-analysis, the studies it compared its results to often used dogs as their animal of choice, given their high trainability. But, even when testing using other animals, dogs were still shown to have a greater chance of effectiveness as a treatment. While this study cannot definitively answer why or how AAT is effective for different populations, it can declare that, yes, AAT is an effective treatment method and whether specific patient or treatment characteristics influence the effectiveness of AAT, it answers, "not in a significant manner."[15].

Biologically Female Populations

Another study testing the effectiveness of animal interactions for different populations, tested changes in oxytocin levels in biological males and females after interaction with a dog. This study used the comparison of oxytocin levels in participants while reading as a control, as shown in figure 2. Blood samples were taken before and after interacting with a dog and reading a book. Again, these effects might translate to interactions with other animals, but this study only investigated dog-human interactions.

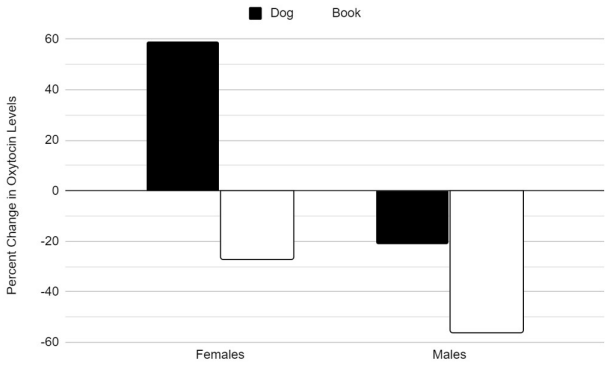

Fig. 2 Oxytocin Levels in Women And Men After Reading And Interacting With a Dog

Note. This figure illustrates the percent change in oxytocin levels from before to after interaction with a dog or reading a book in both men and women. It utilized 10 men and 10 women pet owners, who were all over the age of 18, employed, and Caucasian. The results of this study were a significant 58.4% increase in oxytocin after interaction with a dog, compared to a 26% decrease in oxytocin levels after reading a book. For men, there was a 21.5% decrease in oxytocin levels after interaction with a dog, but a 56.3% decrease after the reading condition[2].

The results of this experiment reveal that oxytocin levels in females rose significantly after interacting with a dog and dropped slightly when reading a book. But, in male, oxytocin levels lowered after interacting with a dog, but lowered less than post-reading. One explanation the researchers in this experiment gave for these results was related to sex hormones: estrogen and testosterone. Estrogen is a strong stimulus for the production of oxytocin and causes it to have a longer effect in females than in males. Another explanation given was that these results support the hypothesis that oxytocin levels are dependent on state, specifically they are related to a calm and relaxed state. Due to women's tendency to "tend and befriend" they are more likely to enter into a calm and relaxed state when in the presence of a dog in forming a connection. This study does not directly relate to AAT, but does give needed insight into populations that could find AAT a more effective treatment option and why this may be. This study also has a very small and limited sample size, meaning there is more room for biased results[2].

Neurotransmitter	Change observed	Relevant studies
Dopamine	Increased levels with animal interaction	J. S. Odendaal (2003)[16]
Endorphins	Increased levels with animal interaction	D. A. Marcus (2013)[14], S. C. Miller et. al., (2009)[2]
Oxytocin	Increased levels with animal interaction	A. Beetz et al., (2012)[13]
Cortisol	Decreased levels with animal interaction	A. Beetz et al., (2012)[13]

Table 1 Summary of AAT Neurotransmitter Studies and Observed Changes

Discussion

Populations likely to benefit from AAT

For the most part, AAT has the potential to benefit anyone of any population. My review did not identify any research to suggest that AAT would fail to benefit any specific population, though there has not been testing done on those afraid of animals or individuals who are allergic to animals. However, we do see some differentially strong effects for certain populations. Namely, women – in comparison to men, women benefit more due to the correlation of estrogen to increased and prolonged oxytocin levels and women's nature of bonding and caring for things. Additionally, in comparisons of neurotypical versus autistic populations, stronger effects in autistic populations are found especially pronounced in younger populations. In older populations, the differential effect is less strong. To conclude, AAT may be a more effective first line treatment for younger populations and populations with autism and this means it would be helpful to educate people in diagnostic positions, or treatment recommendation positions, so that they are more likely to recommend AAT as an earlier treatment option for their patients.

Specific Advantages of AAT-adapted interventions

From a clinical standpoint, informing mental health professionals on the effectiveness of AAT can help them better tailor treatment to patients. Some clinical therapists already use therapy animals during sessions to let patients feel more at ease and more open to talking about difficult subjects. Another prescription of AAT is encouraging patients to look into getting a psychiatric service animal. These animals, most commonly dogs or miniature horses, are trained to perform specific tasks for their owners in order to help overcome their mental health disorder, in severe cases. Psychiatric service animals can be trained to perform deep-pressure therapy (laying on their owner's lap in a certain way to make them feel more relaxed), detect and intervene before panic attacks, bring or remind owner's to take their medications, and stand in certain positions around their owner to create physical separation from other people in public areas. Service animals can be an incredibly effective treatment for those with severe mental health disorders and can allow them to feel more comfortable leaving the house. Mental health professionals can also inform workplaces, schools, and hospitals about the positive effects AAT has. In these specific stressful settings, many people can benefit from a visit from a trained therapy animal. As such, the current findings, that AAT is widely applicable and has many salient advantages across populations, has widespread clinical significance for the health care system broadly.

State of the Research

Variability of Methods across AAT Research

The primary methods of studying the efficacy of AAT are surveys and neurotransmitter studies. Surveys have many strengths and are widely regarded as the most effective method of data collection in psychological studies. They allow researchers to get a self-report of feelings and behaviors from participants that reflect their attitudes and perceptions. In AAT studies using surveys, the results found that people reported feeling calm and less anxious when around an animal.

Gold-Standard Methodologies in AAT Studies

Whereas surveys can be used as a more qualitative data collection method, neurotransmitter studies could supplement insights drawn from survey studies by introducing more quantitative approximations. Neurotransmitter studies have the advantage of helping researchers understand how neurotransmitters relate and correlate with observable behaviors. This advantage is not limited to AAT studies, as it generally helps grow psychological research and understanding of what neurotransmitters are and how they behave in the human brain. In the context of AAT research, the most common neurotransmitter studied was oxytocin. In many studies, its levels were found to increase when people came in contact with an animal. Therefore, in the ideal study, survey and neurotransmitter research methods would be combined to show both the physical and neurological effects AAT has on humans. Specifically, based on this research it is recommended that future research incorporate a longitudinal two (or more) time point study design, with a large population of individuals from varied backgrounds, particularly in terms of age and neurotypicality. This ideal study would also incor-

porate the gold standard randomized control methodology, in which participants are randomized either to AAT or an active intervention of some kind. One possible active intervention that would provide a useful standard of comparison is an expressive writing intervention, for example. Expressive Writing interventions, like AAT, are self-led and potentially relaxing. Comparing AAT to expressive writing in a randomized control trial with a sample like the one described could reveal the unique effects of AAT compared to another comparable active intervention, across demographics. Methods for data collection could include pre and post intervention (animal interaction or expressive writing activity) timepoints during which individuals both supply a blood sample, to test for neurotransmitter levels like oxytocin, and complete surveys that measure their anxiety and depression symptoms.

Limitations

While this study has many strengths, and in particular, highlights the potential of a currently underutilized but very promising transdiagnostic intervention, the study also has a few important limitations. One important conclusion that can be drawn from this review is that there may not be many strong studies on this topic. This fact is first and foremost an important finding that can inform the field and future research by highlighting an area in need of more investigation. However, that research was relatively limited and also introduces some bias in terms of the conclusions we are able to draw from them. Once more diverse and robust research on the topic does exist, an updated review may present new and different conclusions. Furthermore, even fewer multimethod studies exist on this topic, blending strong quantitative and qualitative methods for answering these questions. Specifically, there have not been very many neurotransmitter studies done on this topic, limiting comparable statistics that could be used to further research or discover more. The current review provides evidence that more research on this topic in general, but especially multimethod research is sorely needed. Additionally, most studies looked at interactions with dogs, and future research should incorporate other animals; perhaps even compare efficacy of animal-assisted therapy across animal kinds.

Additionally, research was done exclusively on Google Scholar, which is a reputable peer-reviewed research search engine. However, the search was not duplicated on a second search engine of the like. Therefore, the results of this research may be limited in scope or omit important research that would have been present on a different search engine. Secondly, key word selection is inherently subject to bias. Given the subjectivity involved in selecting search terms, it is possible that another research team would have generated different search terms to address this question, even after reading the same initial articles from the same search engine. Therefore, bias on the level of both research availability on the selected search engine, and on the level of search terms subjectively selected, brings the generalizability and validity of conclusions into some questions. Yet, comparable bias is relatively standard across reviews like this one. Nonetheless, this research could have been improved had the search been replicated on another reputable peer-reviewed search engine, like PsycInfo. A process like this would help to assure that as much relevant research on the topic was captured as possible.

In addition, other limitations of this research include that most research found on the topic is relatively old. This finding, however, shows the necessity for more studies to be conducted as the knowledge in the psychology and neuroscience fields have grown.

Conclusion

The best science integrates both qualitative and quantitative methods. On this topic, the results of this literature review support a blend of both survey and neurotransmitter measures as optimal methodology for assessing AAT efficacy. Research that does this in a sophisticated way is lacking. In fact, this review only identified a few studies that did. This dearth, coupled with the fact that mental health needs are so high, portrays an especially dire need to investigate alternate approaches to treatment, like AAT. AAT is a strong alternative or supplement for other forms of treatment like medication or talk therapy, and findings broadly suggest that AAT may uniquely benefit populations like women and children with autism – these findings are predominantly based on survey data, but some emerging NT evidence has supported these findings specifically in populations of children with autism. These are populations that are historically excluded from scientific study of intervention science. Therefore, future studies should investigate the validity of these findings, and if more evidence is found that AAT offers unique benefits for these populations, should investigate options for improving scalability, incorporating it into early steps in care especially for certain populations, so as to tailor treatment to individual needs.

Methods

To address the research question of the neurochemical changes that are observed in humans over the course of animal-assisted therapy, and how they provide uniquely improved outcomes for specific populations, a literature review approach was implemented. To investigate this question, the following steps included: first, conducting a brief initial literature search to identify key words to be used for further research. Forming these keywords around the research question, a more comprehensive search on Google Scholar will be conducted, to ensure

all literature is peer-reviewed research. Studies identified were included if they were peer-reviewed, and if 1) subject matter was relevant to inform background on animal-human interaction, and 2) provided empirical evidence, like from a randomized control trial, of outcomes associated with AAT such as change in levels of neurotransmitter. An inventory of the scope of research that currently exists on this topic was taken and relevant studies were filtered and compiled. Next, with this compilation, notes comparing and contrasting the different studies were taken in order to have a catalog of what each is about and what they can be used for in the context of this paper. Using all of this research, main topics were generated for discussion in this paper. This literature review resulted in a paper that includes a summary or index of research and findings existent in the literature and highlights any holes in literature that require more study and it will be closed with a limitations and future directions section. Due to this paper's relevance in the world of psychological studies, an APA citation style was used.

Acknowledgments

I would like to thank my mentor Madison Schmidt of Northwestern University for her support in introducing the scientific process for writing research papers, her help in idea generation for this paper, and her writing support. I am grateful for my publication strategist Anustup Garai who assisted in identifying a publication target. Finally, I would like to thank my program manager Anish Kumar for his organizational and logistical support in writing this paper.

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