PERSEVERANCE: 1995-2015

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WICHITA STATE UNIVERSITY

McNair Scholars Program

Journal of Research Reports
2015-2016 • Volume 20

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From the Director

It is with great pleasure that I present Volume 20 of the Journal of Research Reports, "Perseverance: 1995 – 2015," where the McNair Scholars Program has proven to make a difference in the lives of the students served. As you take the opportunity to read through the multidisciplinary works of the students, it is clear that the breadth of research interests is as diverse as the students being served through this Program. The staff and I are very proud of the efforts that went into producing such a scholarly body of work.

The Program can only achieve such great accomplishments with the support of University faculty, staff and administrators. These mentors have guided and inspired the McNair Scholars in completing their research projects and reaching great heights. Their efforts are applauded for their dedication to making undergraduate research a reality and supporting the students from the McNair Scholar Program along the way.

In this journal, you will find the work of twelve (12) undergraduate students who are being showcased for the work they have done and their commitment to go beyond the classroom. There are three (3) full manuscripts and nine (9) summaries. These research activities serve many purposes: to cultivate and develop research skills, provide experience conducting scholarly research and to create and develop relationships with faculty that could potentially assist students in applying, enrolling and being admitted into graduate programs where they will pursue and complete a graduate degree. All of these skills, along with many other attributes, make McNair Scholars more attractive to degree granting institutions, and these activities lay a great foundation in assisting the students in their pursuit of doctoral studies.

A special thank you is given to the staff for their dedication to the Program and the students that we serve. *Mr. Matthew DeAnglis,* research coordinator. *Ms. Sara Vora* and *Mr. David Caylor* who served as writing tutors. *Ms. Ashley Cervantes*, program counselor and student confident. *Ms. Neshia Greene*, senior administrative assistant and all around Program support. Lastly, *Ms. Deltha Q. Colvin*, associate vice president for Student Affairs; who provides unending support for me as the director.

Finally, I congratulate the students for a job well done; their efforts do not go unnoticed. They have taken this opportunity to share their brilliance with the academic community. These students are our future educators and I thank them for the opportunity to serve as their director.

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Research Papers

An Attempt to Implement Explicit Parallelism to a Dynamic Learning Algorithm for Calculating Entanglement

Kevontrez Jones
McNair Scholar, Wichita State University

Elizabeth Behrman, PhD
Professor of Physics

A quantum neural network is a device, model, or system that uses the properties of biological neural networks and combines them with quantum theory. Currently, the field of quantum computing is still in its infancy. This study aims to implement parallel computing to speed up the computations dynamic learning algorithm, which is an essential part of such a network. The algorithm examined was developed to calculate quantum entanglement amongst a pair of pure quantum states. The algorithm is capable of learning how to calculate the entanglement through training a set of given weight parameters via the time evolution of a known quantum state, then applying what it learned to calculate the entanglement of a new state. An attempt to speed up the training and testing of this dynamic learning algorithm was done through explicit parallelism. Through the usage of Wichita State University's High Performance Computing Center (HiPeCC), the algorithm was parallelized across a computer cluster system, ranging from two to eight CPUs. Then the execution times of the cluster systems were compared to those of the single machine case for a number of qubits, ranging between two and six. It is anticipated that as the number of CPUs being used increases, the time required for the computations will decrease. The aim of this research is to help further develop the field of quantum neural networks, which have the potential to deepen our understanding of brain functions and add new abilities in information processing.

Nomenclature

QNN	= Quantum Neural Network
DLA	= Dynamic Learning Algorithm
CPU	= Central Processing Unit
GPU	= Graphic Processing Unit
HiPeCC	= High Performance Computing Center

I. Introduction

The quantum neural network is a device, model, or system that uses the properties of biological neural networks and combines them with quantum theory. The field of quantum computing is still in its infancy, but it has gathered significant attention for the possible applications it presents. To understand how a quantum neural network works, one must understand the derivation of the concept. A neural network is a model of interconnected units based on biological neurons feeding signals into one another. Most of these networks reduce the intricate process of signal transmission in neural cells to just two states by using binary McCulloch-Pitts Neuron [1,2]. This is analogous to the two-level qubit which serves as the base unit in quantum computing, and, thus, gives a connection between the neural network models and quantum theory. Hence, the vast majority of the proposed quantum neural networks have been based on the concept of a qubit neuron and theoretically constructed neurons as two-level quantum systems.

In the world of computation, there are two different types of computers: the classical computer and the quantum computer. The classical counterpart was developed first, and then its quantum counterpart was developed to address the limitations of the classical version. Demand for quantum computation arose because of the limitations in the hardware implantation of classical computation. Classical computers can efficiently process numbers and symbols with relatively low bit registers, but they struggle with pattern processing. In order for a classical computer to handle process patterning, they require massive gates of order d [4,8] according to Rent's Law to process d-bit reg-

isters [4]. However, typically, a computer program requires operators on the order of 2^d in order to perform universal calculations on patterns [6]. Unfortunately, this feature makes it impossible for classical computers to solve pattern processing through algorithms. One device which can address this shortcoming is an artificial neural network because it uses architecture which is capable of processing long bit strings and learning by example rather than programming. Another strength of the artificial neural network is that it features parallel distributed processing and robustness.

The artificial neural network not only addresses limitations within classical computers but also quantum computers. Quantum computers deal with the quantum analog of classical computational architecture, which is comprised of quantum bits and quantum gates. Naturally, quantum computers inherit several features from their classical counterparts. For example, they are unable to operate wide band signals and cannot be trained by examples. Hence, their efficiency predominantly depends on their quantum algorithms. Classical neural networks have also been known to face problems such as absence of rule for optimal architectures, time consuming training, and limited memory capacity. However, quantum computers inherit a parallel distributed processor with exponential memory capacity and are easily trainable due to the quantum mechanical nature of physics that is used to construct them. Despite these advantages, quantum computers are still plagued with severe hardware limitations. Also, quantum computation uses a linear theory, whereas artificial neural networks use a nonlinear approach.

These help give rise to several important concepts within the field of artificial neural networks. One of which is the processing element, which acts as a neuron. Some other concepts are the transformation performed by the element, the interconnection structure between the neurons, the network dynamics, and the learning rule which governs the modification of interaction strengths [7]. Hence, it is believed that a solution to overcoming the difficulties of classical computers, quantum computers, and

neurocomputers comes in the form of quantum neural networks. As previously stated, these networks arise from a combination of quantum computation and neural computation. The strengths of the artificial neural network were previously noted regarding its distributed processing of information and nonlinearity of the transformations performed by the neurons. However, the quantum mechanics' nature within quantum computation offers the possibility of an even stronger quantum parallelism, which is conveyed in the principle of superposition. Hence, quantum neural networks have the potential of being powerful computational devices. The quantum computing principles of quantum computation and the algorithms in neural networks can be applied together to allow big data sets to be efficiently processed. Consequently, quantum neural networks inherit the important role of being intelligent computational methods for pattern recognition and learning from artificial neural networks [8].

Entanglement is a quantum mechanical consequence that arises from the concept of superposition. Naturally, one would believe that when superposition is destroyed, there would no longer be communication between the qubits. However, due to entanglement the proper correlation is still able to be efficiently communicated. This is one of the advantages that quantum mechanics brings to quantum computation. This is because the power of quantum computation comes from the exponential state spaces of multiple quantum bits. A single bit can be a superposition of 0 and 1, since it is defined as a complex bi-dimensional unitary vector consisting of the computational basis of the |0> and |1> vectors. Conversely, a register of n qubits can be a superposition of all 2^n possible values. Hence, there exists a surplus of states, which are entangled and do not have a classical equivalent. These states are responsible for the exponential size of the quantum state space, and they are mathematically defined by a density matrix formalism [17].

Kak [3] was one of the first to publish research that featured applying a quantum approach to a neural network. In his work he introduced the idea of "quantum neural computation" by inter-

preting the necessary condition for a stable state in a 'Hopfield-like' network be defined by a weight matrix, with entries as an eigenvalue of a quantum system. Updating such a system can lead to a quantum measurement that selects its eigenstates. He also felt that the sigmoid function was a nonlinearity and it did not have an analog in the quantum mechanical formalism.

Peruš [9] had a similar idea to that of Kak in that he believed there was an analog between a 'Hopfield-like' network and quantum theory. Also, he thought of an updating function that had a time-evolving quantum system, but did not possess a threshold or sigmoid function. Additionally, he modeled a pattern recall through a collapse of the wave function in which a valid input state is supposed to be almost orthogonal to all basis states, except for one vector that ensures a high probability for the projection operator within the quantum state. The ideas of Peruš provided fundamental foundations to Behrman's proposal of interacting dots for a quantum neural network [11].

Meener and Narayanan [10] also introduced their ideas for a quantum neural network shortly after Kak published his work. However, they believed one should look at the network as a superposition of networks, each storing one pattern rather than a single network storing multiple patterns. They proposed this network of quantum states be given by its weight vector. The overall idea stemmed from the many-universe interpretation of quantum mechanics. In their approach a retrieved pattern corresponded to a collapse of the superposition of weight vectors. Through this outcome, a single network is chosen and it retrieves the desired result. Hence, this collapsing mechanism would result in choosing the single network that stored the pattern which best resembled the input pattern.

As mentioned previously, the notions provided by Peruš were used to develop the QNN proposal by Behrman et al., which has been one of the most significant proposals so far. They took the Green function used by Peruš and reformulated it using a Feynman path integral which summed all the possible paths of the time varying state and propa-

gated the system from one state to another. Instead of different querons, the network is realized by the propagation of a single queron. Also, its state after each of N's different time slices simulates the state of N's virtual neurons. The synaptic weights are then engineered by interaction of the 2-level queron with an environment. Hence, instead of updating the state of a neuron by the state of N-1, the state of one neuron at given time is influenced by its states at the other times. Behrman et al. proposed to implement this time-varying neural network through quantum dot molecules interacting with phonons of a surrounding lattice as well as an external field that leads to a potential V(r). The network can also be trained by a common backpropagation rule where the weights are corrected according to the output error gradient.

This notion has gained a great deal of popularity because it addresses the incompatibility problem between neural and quantum computing. Also in their work, Behrman et al. found out the non-linearity of a neural network's dynamics arises naturallyinthetimeevolutionofthequantumsystem through the exponential function and the non-linear kinetic energy that feeds into the potential V(ϕ,t). However, they also stated that for computations that are larger than simple gates, such as the advanced properties of the Hopfield network-like pattern recognition and associative memory, a spatial-array model is needed. Such a model has been proven to possess noteworthy features, such as the computation of quantum entanglement or its own phase [5,12]. Nonetheless, it has not yet been implemented as a device for quantum associative memory. The proposal by Behrman and her group also showed that the natural evolution of a system of interacting quantum dots can serve as a quantum neural computer in that the desired mapping input to an output can be engineered under certain conditions. Consequently, any quantum system with an evolution dependent on the initial state and with appropriate parameters is some kind of analog computing device for a given problem, just as any input-dependent physical system can be seen as an analog computer. Hence, it is debatable that their proposal meets the second requirement set by Maria et al. for a feasible quantum neural network.

The field of quantum neural networks is still relatively new, and it developed from the hope of combining the best aspects of artificial neural networks and quantum computation. Currently, there are not any fully developed models, but there have been several proposals presented by researchers. The overall goal is that the quantum neural networks will create the possibility of efficiently working with extremely large computations. Also, they would allow us to solve highly complex problems that we currently are unable to solve using present technology, some of which are described by Smelyanskiy et al. [13]. One example of such a complex problem would be an artificially intelligent space vehicle that is sent to another planet to explore the environment. Such a vehicle would need to be programmed to recognize different terrains and depths and be able to learn from its interactions with the environment. There are several tough problems such as these that demand technology that is more advanced than what has been currently developed. Distributed parallelism is another tool that is generally used for computationally intensive problems, and it has two forms. One form is referred to as implicit parallelism where a multicore CPU utilizes its several cores to perform computations simultaneously. The main limitation of this approach is the number of cores that can be applied to a single machine. In the present study, explicit parallelism was used, where computations are done in parallel across several CPUs in a supercomputer cluster. Hence, the aim of the present study was to further advance the field of quantum neural networks by applying explicit parallelism to a pre-existing proposed model to optimize its capabilities.

II. Methodology

The dynamic learning algorithm used in this study was previously proven to calculate the entanglement of pure states with a varying number of

qubits. This paper will give a general overview of the algorithm, but a more detailed explanation of its derivation can be found in previously published works [15-17]. Essentially, the algorithm starts with a known quantum state, which is determined by the bell state, flat state, c state, and p state. From the initial states of the bell, flat, c, and p states, initial density and Hamiltonian matrices are created. Then the initial state of the density matrix is mapped to the final state through time evolution, which utilizes a time integrator and the product of the Hamiltonian and density matrices at each time step to determine the final density state. Once the initial state is mapped to the final state via a forward propagation in time, the final state is propagated backward in time to train the weight parameters of the bell, flat, c, and p states. Through this training of the parameters, the algorithm is capable of learning how to calculate the entanglement of a given state on its own. Hence, the first calculation was done on a state where the exact values of the entanglement were already known, and the results of the algorithm were compared with the known exact values. The error in difference between the two is then measured. Once the error is proven to be in an acceptable range, the entanglement of unknown states can be computed as well. Nevertheless, the algorithm is currently only able to calculate the entanglement of pure states due to problems in normalization errors of the density matrix and a proper determination of its initial values.

However, the entanglement-calculating algorithm was a device developed via the usage of MATLAB & Simulink [14]. Therefore, it could be parallelized through the usage of the distributed computing server and the parallel computing toolbox within MATLAB. These tools allowed MATLAB codes, such as the dynamic learning algorithm previously described, to be run across several available CPUs within an available supercomputer cluster or cloud cluster. Ideally, the parallel computations could be used in order to reduce the execution times of the algorithm by taking the work of a single CPU and distributing it across several others. The idea for this approach is that two is faster than one, but the road to parallelization is not always a simple one, so in this case it was done through a three-step process. Originally, the algorithm used simulations developed in Simulink to do the forward and backward propagations in time, which were used to train the weight parameters. This was problematic because Simulink is largely seen as a single-CPU process. The only way it could be calculated in parallel was via a parallel for-loop, which would need an asynchronous code. Nevertheless, in order to evolve in time, the integration required that the density state at the previous time-step be known to calculate the one for the next time step. Thus, the simulations could not be done asynchronously due to the dependent nature of the integration used in the simulations to do the time evolution.

For this reason, the first step of parallelizing the entanglement-calculating algorithm was to abandon the Simulink simulations and replace them with pure MATLAB-coded functions which would yield the exact same results. The step-by-step routine used by the Simulink simulations was recorded and converted into MATLAB-scripted functions. Once completed, the code was run with the simulation calls enabled for various numbers of qubits and training sequences, and the results of the trained parameters and density states were recorded. Then the simulation calls were replaced with the newly developed MATLAB function calls, and the algorithm was again run with the same cases used with the simulation calls. The two were then compared. Proving that the time evolution of the pure-MATLAB version of the code matched with that of the MATLAB/Simulink-mixed version, the first step was completed.

The forward and backward propagations were the main segments of interest because they are used to train the parameters, and they are the essence of the algorithm. So after successfully converting these processes into MATLAB functions, the next step was to modify them so that they could be computed across several CPUs simultaneously. Again this could be done using a combination of the parallel computing toolbox and

the distributed computing server that are within MATLAB. Within these tools there are several functions that could be used to run a code in parallel. However, due to problems explained with the Simulink simulations, it was determined that the best tools to use would be the 'codistributed' and 'SPMD' functions. By using these two in combination, any vector or matrix state could be split across all available CPUs. Additionally, any calculations involving them could then be forced to be done simultaneously across the all the CPUs used. This would prove to be the best way to enforce explicit parallelism upon the algorithm. Refer to Table 1 for a more detailed explanation of how the matrices were distributed across the multiple CPUs in the HiPeCC cluster for each qubit case considered.

Multi CPU Case			
Qubits	CPUs	Matrix Product (sec)	Near-Full (sec)
2	2	94,5042	395,6508
	4	126,5728	619,1922
	8	170,8496	990,0304
3	2	96,2564	451,1
	4	128,3432	722,4154
	8	207,597	1190,891
4	2	96,2564	451,1
	4	128,3432	722,4154
	8	207,597	1190,891
5	2	96,5398	489,3318
	4	129,9588	748,3746
	8	209,5386	1220,269
6	2	96,7212	503,1086
	4	131,415	677,6048
	8	202,356	1153,396

Table 1: Breakdown of Distribution of Density and Hamiltonian Matrices across CPUs for Various Qubit Cases

Therefore, for parallelization, both the forward and backward propagation functions were modified such that they included the 'codistributed' and 'SPMD' tools. Although these enforced explicit parallelism, the parallelized functions still had to be shown to yield the same results as their non-parallel counterparts. Once again, runs with the two were done using various qubits and training sequences, and their final results were compared. After proving that the parallelized functions and the non-parallelized functions were giving the same results, the second step was completed. The final step was to collect data.

Since the main purpose of using explicit parallelism was to speed up the algorithm's computations, data was collected by running the algorithm and recording its execution time using MATLAB's profiler tool. First, the times were recorded for the "1 CPU" case, where the full algorithm was run with both the Simulink simulations and MATLAB scripted functions. Using Wichita State University's High Performance Computing Center (HiPeCC), execution times for the parallelized forward propagation function were then recorded for qubits ranging from 2 to 6. In one case the parallelized aspect of the functions was focused only on the matrix product within the function, and in the another case all of the code except the integrator was focused upon. Originally, the aim was to parallelize the entire function, but due to the current state of MATLAB's distributed computing server, the integrator section could not be done in parallel because to a lack of proper communication between the CPUs. Essentially, this is the same problem that was seen with the Simulink simulations of the single CPU case. The integrator is a vastly dependent process that requires precise and accurate communication between the CPUs being used to be calculated correctly. However, with the current technology the CPUs are incapable of meeting this communication requirement, and the integrator is consistently incorrectly calculated.

For the explicit parallel computations, the execution time for the forward propagation was recorded for a cluster of 2 CPUs, 4 CPUs, and 8 CPUs. This was done for both the cases mentioned above, where the nearly-full function was parallelized and only the matrix product was parallelized. Execution times were also recorded for the full algorithm utilizing the both functions (with parallelized matrix products) for the 2 and 3 qubit cases. Again, these were done on clusters of 2 CPUs, 4 CPUs, and 8 CPUs on the HiPeCC system. In the

non-parallelized single CPU case all the runs were done on the full algorithm for all qubits ranging between 2 and 6. For consistently, the exaction times for all the cases considered in this study were recorded five times, then averaged.

III. Results

A. 1 CPU Case

For the single CPU, execution times were recorded for the full algorithm under two conditions, the first being that the forward and backward propagations were called by Simulink simulations and in the other they were called by MATLAB user-defined functions. Since this is a single CPU comparison, no parallelization was done. Also, the comparison was done for all qubits ranging from 2 to 6. The main difference between the various qubits is the size of the vector and matrix states. These scale as 2^N, where N is the number of qubits. Consequently, as the number of qubits increases, the size of the vector and matrix states exponentially increase. It should also be noted that due to the nature of the algorithm, the number of times the calls are done increases as well.

From the results in Table 2, the algorithm utilizing function calls is consistently faster than that of the one utilizing simulation calls. Also, it is clear that the difference in execution times between the two exponentially increased with the number of qubits increasing. Thus, the results suggest that at small qubits either method can be used, but at larger qubits it quickly becomes apparent that the MATLAB function calls are far more efficient.

The main reason behind these differences in time is that Simulink lives in a separate environment from that of MATLAB. In the case of the algorithm utilizing Simulink, each time the simulations are called, the program must jump out of MATLAB and into Simulink. Once inside Simulink, the code utilizes a block-diagram architecture. Upon completion, the code moves out of Simulink and back into MATALB. First, MATLAB must communicate with Simulink and give it all the initial conditions

1 CPU Case		
Qubits	Simulations (sec)	Functions (sec)
2	10,3138	8,3274
3	20,5388	16,442
4	58,944	50,6284
5	209,7248	158,0342
6	1083,0588	684,1566

Table 2: Comparison of Execution Times of the Full Algorithm Utilizing Either Simulation Calls or Function Calls for a Single CPU

for the vector and matrix states. Then at each time step Simulink must communicate with MATLAB and give it the results of the Hamiltonian and density matrix. This constant communication between the two environments creates computational overhead, which significantly increases as the number simulation calls increase. Table 3 showcases how the number of times the simulation and functions are called for each qubit case. The problem of overhead is not observed with the algorithm utilizing the function calls because all the computations is done within the MATLAB environment. Additionally, the functions utilize a hard-coded architecture rather than one with block diagrams. Although the size of the data increases exponentially, the data never becomes too large. The max size of the matrices is [64x64] and the vectors are either [2x64] or [4x64], which is seen in the 6 qubit case. Nevertheless, it will be shown in the later sections that these sizes of data are not large enough to significantly affect the execution times of the function calls. This suggests that the main mechanism responsible for increasing the execution time of the algorithm as the qubits increase is the increase in function/simulation calls.

B. Multi-CPU Case

In the multi-CPU case, execution times were recorded solely for the forward propagation function and two configurations were considered. In the first configuration, only the matrix product of the Hamiltonian and density matrices is parallelized and in the other, the entire function except the integrator is parallelized. Similar to the

Forward and Backward Propagation Calls for Qubit Case		
Qubits	Forward Propagation Calls	Backward Propagation Calls
2	8	4
3	26	13
4	58	29
5	112	56
6	204	102

Table 3: Tabular Representation of Function/Simulation Calls for All Qubit Cases Considered

Multi CPU Case			
Qubits	CPUs	Matrix Product (sec)	Near-Full (sec)
2	2	94,5042	395,6508
	4	126,5728	619,1922
	8	170,8496	990,0304
3	2	96,2564	451,1
	4	128,3432	722,4154
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	8	207,597	1190,891
5	2	96,5398	489,3318
	4	129,9588	748,3746
	8	209,5386	1220,269
6	2	96,7212	503,1086
	4	131,415	677,6048
	8	202,356	1153,396

Table 4: Comparison of Execution Times of Parallelized Forward Propagation Function with Multiple CPUs

Single CPU case, the computations were done for all qubits ranging between 2 and 6. Though, this time the forward propagation function was run on a cluster 2 CPUs, 4 CPUs, and 8 CPUs. The reason execution times were recorded solely for the forward propagation was because the forward and backward propagation functions are the same, computationally speaking. Their usage and functionality may vary, but their mathematics are identical. Also, the goal was to identify which of the two configurations would prove to be faster, so full algorithm runs would be unnecessary.

From Table 4 the version that utilized parallelization solely for the matrix product was significantly faster than the other. It can also be seen that, generally speaking, there is no increase in execution time as the number of qubits increases. Therefore, as hinted at earlier, the increase in size of the matrices and vectors that occurs as the number of qubits increase has little to no affect upon execution time. The only time a significant change was observed was the 8 CPU case when going from 2 qubits to 3 qubits, where an increase of close to a minute is seen. Though interesting, the real unexpected result is that as the number of CPUs in the cluster increases, so does the execution time of the function. This is observed for all qubits and for both of the parallelized configurations considered. The reasoning behind this is similar to that of the Simulink-calling version of the algorithm in the single CPU case–communication across separate entities.

In the case of using multiple CPUs, the CPUs within the cluster must communicate both to each other (the workers) and the main CPU outside the cluster (the client). Once again, there is an issue of separate environments except this time the separate environments are those of the different CPUs. Now the client must first take the matrices and vectors and distribute them across the workers. The workers then do whatever calculations they are asked to do, while communicating their pieces of the matrices and/or vectors to one-another. Next the workers must report back to the client so that it can gather up all the pieces into single entities. This is done at each time step of the time evolution. Having to repeatedly communicate to each other and to the client grossly increases the execution time of the function. In the near-full parallelized version of the function more data must be communicated than the matrix-product version. For this reason, the execution times between the two configurations is grossly more for the near-full parallelized version.

C. Combined Comparison

After recording the execution times of both the single CPU case and the multiple CPU case, the results of the two were combined for a final com-

parison. Since the parallelized matrix-product version of the function proved to be the faster of the two configurations considered, it was used for comparison with the non-parallel case. This was done by applying the explicit parallelization of this configuration to the full algorithm and recording the execution times. Meaning that since the full algorithm was being worked with, both the forward and backward propagation functions were parallelized with a focus on the matrix-product.

As seen in Table 5, the explicit parallelization did not prove to give any speedup of the dynamic learning algorithm. In fact, it did the opposite–the execution time significantly increased. Also, as foreshadowed by the multiple CPU case described above, there was an increase observed with an increase in workers utilized. Therefore, based on the results from the other two cases, it was decided that recording execution times for qubits ranging between 4 and 6 would prove to be time consuming and give no further indication of speedup. In the single-CPU case, the execution time of the algorithm increased as the number of qubits increased because of an increase in function/simulation calls. In the multi-qubit case, the execution time of the forward propagation itself increased with the number of workers due to overhead. Hence, it can be concluded that if more parallelized runs of the full algorithm were recorded the execution times would simply increase exponentially and speedup would not be achieved.

Combined Comparison		
Qubits	CPUs	Execution Time (sec)
2	1	8,3274
	2	1110,1444
	4	1557,5224
	8	2134,1588
3	1	16,442
	2	3601,5522
	4	5134,7392
	8	8117,7562

Table 5: Comparison of Execution Times for Parallelized and Non-Parallelized Full Algorithm

IV. Discussion

For the case of the entanglement-calculating dynamic learning algorithm used in this study, there was no speedup observed when implementing explicit parallelism upon it. Due to the large amount of overhead from communicating across several entities, the execution time drastically increased. Although, explicit parallelism was created solely for the purpose of speedup, it does not always meet this goal. In the case of the algorithm used in this study, the problem was that the data was too small. Explicit parallelism works best for computationally-intensive data which is too large for a single CPU to handle on its own. Generally, this type of data is so large that it breaches the memory limits of the single machine. Yet, it was seen in the single-CPU case that the machine had no problems doing computations with the algorithm for all qubits considered. Therefore, explicit parallelism proved to be overkill and unnecessary.

This would suggest that, in order to fully utilize the capabilities of explicit parallelization, the number of qubits the algorithm can operate on must be increased. Consequently, this restriction on data size proved to be one of the major limitations of the study. The algorithm had only been configured to operate on a maximum of 6 qubits, meaning the maximum size of the matrices being multiplied together in parallel was only [64x64]. As mentioned earlier, these matrices are square and they scale as 2^N. Thus, the data being parallelized exponentially increases as the number of qubits increase and [64x64] matrices are simply not big enough to push the limits of a single machine. For a future study, it would be best to use explicit parallelization on such an algorithm which can operate on a larger range of qubits.

Also, this study focused upon a supercomputer cluster as a means of distributed computing, but graphic procession units (GPUs) are another possible means that could be used in future studies. In the case of GPU computing, the GPU and the CPU work together in order to accelerate the

execution time of a code/device. This is done by allowing the GPU to handle the computationally-intensive portions while the CPU handles the rest. In the case of the entanglement-calculating algorithm used in this study, the GPU could be used to do the forward and backward propagations while the CPU handles the rest. This is similar to what was attempted with the HiPeCC supercomputer cluster. The computations done by the GPU is still considered a parallel computation because it generally has a massively parallel architecture consisting of thousands of small cores. Though smaller than the cores of a CPU, these GPU cores are designed to handle multiple jobs simultaneously. Another benefit is that the CPU and GPU operate on the same machine. Therefore, GPU computing is a possible means of distributed computing that should not suffer the same overhead problems as seen with the super computer cluster used in this study.

Though distributed computing may be used to help further advance the young field of quantum neural networks, it is possible that the field needs more time to be further developed before its full capabilities can be utilized. Since a quantum neural network must be able to learn from its experiences, a proper dynamic learning algorithm is essential to its existence. For the time, the one used in this study is fairly advanced. Nevertheless, it has not been developed far enough to appropriately employ the abilities of a supercomputer cluster. It is believed that quantum neural networks have the potential to deepen understanding of the brain and further advance information processing. However, since the field is still in its infancy, it must be further developed before current advanced technologies can be proven to be capable of accelerating a feasible quantum neural network into existence.

V. Conclusion

In this study there was an attempt to implement the capabilities of the explicit parallelism of a supercomputer cluster to speed up a dynamic learning algorithm, which is an essential component of a quantum neural network. The algorithm used in this study had already been previously developed to calculate the entanglement of a pure state system. Once calculating the entanglement of a known state, the algorithm could then be trained to calculate the entanglement of other pure states. Using Wichita State University's HiPeCC system components of the time evolutions required to train the weight parameters necessary to assist the learning of the algorithm was distributed across several CPUs within a cluster. This study only used clusters consisting of 2, 4, and 8 CPUs. Also, the qubits of the algorithm ranged between 2 and 6, since those were the limits of its present operating range. After using two configurations of parallelization, it was seen that focusing solely on the matrix product operation of the forward and backward propagations would prove to provide the best possibility of speed up.

However, after comparing it to that of the single (non-parallelized) CPU case, there was no speed up seen. Instead, there was a drastic increase in execution due to overhead in communication between the workers and the main client. It would appear that the reason for this problem is that the data was simply too small for the usage of a supercomputer cluster to prove useful. It is suggested that this study be done on an algorithm that has a higher qubit operating range. Currently the data is not too large for a single CPU so using additionally CPUs to do the computation proves to be unnecessary. It is also suggested that GPU computing be explored instead of a multiple CPU cluster. These also have the ability to do parallel computations, but they only utilize a single machine. Thus, the overhead in communication should be drastically reduced.

References

[1] Rabinovich, M., Varona, P., Selverston, A., Abarbanel, H., "Dynamical Principles in Neuroscience." *Reviews of Modern Physics*, vol. 78 no. 4, 2006.

[2] McCulloch, W., Pitts, W., "A logical Calculus of the Ideas Immanent in Nervous Activity," *Bulletin of Mathematical Biophysics*, vol. 5, no. 4, pp. 115–133, 1943.

[3] Kak, C., "Quantum Neural Computing" *Advances in Imaging and Electron Physics*, vol. 94, pp. 259–313, 1995.

[4] Landman, B., and Russo, R., "On a Pin Versis Block Relationship for Partitioning of Logic Graphs," *IEEE Transactions on Computers,* vol. 20, pp. 1469-1479, 1971.

[5] Behrman, E., Chandrashekar, V., Wang, Z., Belur, C., Steck, J., and Skinner, S., "A Quantum Neural Network Computes Entanglement," quant-ph/0202131, 2002.

[6] Ezhov A., Shumsky A., "Neurocomputing and its Application in Economics and Business," *Journal of Global Research in Computer Sciences*, Moscow, 1999.

[7] Nayak, S., Nayak, S., and Singh, J., "An Introduction to Quantum Neural Computing," *Journal of Global Research in Computer Science*, vol. 2, no. 7, pp. 50-55, 2011.

[8] Schuld, M., Sinayskiy, I., and Petruccione, F., "The quest for a Quantum Neural Network," *Quantum Information Processing*, vol. 13, no. 11, pp. 2567-2586, 2014.

[9] Peruš, M., "Neural Networks as a Basis for Quantum Associative Networks," *Neural Network World,* vol. 10 no. 6, pp. 1001–1013, 2000.

[10] Menneer, T., Narayanan, A., "Quantum-Inspired Neural Networks" Computer Science Dept., University of Exeter, UK, Technical Report 329, 1995.

[11] Behrman, E., Nash, L., Steck, J., Chandrashekar, A., Skinner, S., "Simulations of Quantum Neural Networks," *Informational Science*, vol. 128, no. 3, pp. 257–269, 2000.

[12] Behrman, E., Steck, J., "A Quantum Neural Network Computes its Own Relative Phase," arXiv:1301.2808, 2013.

[13] Smelyanskiy, V., Rieffel, E., Knysh, S., Williams, C., Johnson, M., Thom, M., Macready W., Pudenz, K., "A Near-Term Quantum Computing Approach for Hard Computational Problems in Space Exploration," arXiv:1204.2821, 2012.

[14] MATLAB & Simulink, Software Package, Ver. 2015b, The MathWorks, Inc., Natick, MA, 2015.

[15] Behrman, E., Steck, J., Kumar, P., Walsh, K., "Quantum Algorith Design Using Dynamic Learning, "*Quantum Information and Computation*, vol. 8, no. 1&2, pp. 12-29, 2008.

[16] Behrman, E., Steck, J., "Dymanic Learning of Pairwise and Three-way Entanglement, "*Proceedings of the Third Congress on Nature and Bioligically Insoired Computing*, NaBIC, pp. 99-104, 2011.

[17] Behrman, E., Steck, J., "Multiqubit Entanglement of a General Imput State, "*Quantum Information and Computation*, vol. 13, no. 1, pp. 36-53, 2013.

The Relationship between Eating Behavior and Self-Perception

Elizabeth Ramirez

McNair Scholar, Wichita State University

Barbara Chaparro, PhD

Professor of Psychology

Abstract

Eating behaviors and self-perception affect a wide variety of people. Does a person's eating behavior reflect on one's self-image? By exploring one's eating behaviors and self-perception, a potential link between eating disorders and mental state can be established. The current study examines the relationship between self-perception and eating behavior among college students at Wichita State University. An online survey was completed by 66 participants. Participants were recruited on campus, through social media advertisements, and the SONA portal. The participants' self-perceptions were assessed using Rosenberg's Self-Esteem Scale and Mendelson's Body-Esteem Scale; eating behavior was determined using the Three-Factor Eating Questionnaire (TFEQ-R18). Contributing to research with these variables can help identify students who are at risk to things such as eating disorders. Understanding the factors that lead people to these unhealthy choices can aid in the production of effective treatment programs. This study explores the relationship between perception and eating behavior among college age males and females, two variables that can easily disrupt someone's mental health and lifestyle. Gaining a better understanding of these risk factors can bring society closer to reducing suicide rates, eating disorders, and self-esteem issues. Findings showed self-esteem to have significant relationships with eating behavior, and the BE-attribution subscale within the Body-Esteem Scale. Significant relationships were also found between the BE-appearance subscale and BE-weight subscale. A strong correlation was found between two of the TFEQ-R18 subscales: Emotional Eating subscale and Uncontrolled Eating subscale.

The Relationship between Eating Behavior and Self-Perception

Only 4% of women in the world believe they are beautiful (Etcoff, Orback, Scott, & D'Agostino, 2004). Society and media essentially tell people how to look and act. This can take a negative toll on people because what is advertised is usually not the reality. Self-perception may be affected by this, especially because of society's beauty standards. Women tend to be the primary focus of self-esteem research because society promotes self-esteem as a feminine struggle.

There is a need to expand research into eating behaviors and self-perception because of the severe effects that can arise, such as eating disorders and depression. Body image is often distorted by the modeling industry, which gravitates towards fairly skinny females to represent all women. The gender ratio of eating disorders between females and males is 10:1 (Hautala et al., 2008). In 1999, the average body weight of a female model was 23% less than the average woman (Kling, Hyde, Showers, & Buswell, 1999). Today, female models are reported to weigh 13% to 19% less than the average women (Christine, 2014). In addition to eating disorders, this study will address problems of self-esteem, which can lead to depression, a condition that affects about 15-20% of teens (Jónsdóttir, Arnarson, & Smári, 2008) and can lead to suicide if no help is received. Eating behaviors and self-perception have a symbiotic effect on self-esteem.

This study investigated these two variables separately and examined how they work together to affect self-esteem. The way people feel about themselves has a direct effect on their actions (Kling et al., 1999). An unhealthy eating behavior is one of the symptoms of eating disorders that can develop from struggling with self-perception. Prevention programs could help reduce the number of students who struggle with self-perception and unhealthy eating behavior.

A measurement tool that is often used to investigate eating behavior is The Three Factor Eating Questionnaire-R18 (TFEQ-R18). It consists of three subscales: cognitive restraint eating, uncontrolled eating, and emotional eating (Anglé et al., 2009). Cognitive restraint behavior is described as intentionally stopping oneself from eating. Uncontrolled eating is to overindulge in food intake. Emotional eating is when an individual lets their emotions dictate when they eat (Anglé et al., 2009). The TFEQ-R18 questionnaire can help determine the eating behaviors of individuals participating in this study; thus, we will be able to explore these behaviors' relationship to self-perception. It is possible that there is a type of eating behavior that can help detect low self-esteem or low body-esteem.

To measure body satisfaction, researchers have also used the Body-Esteem (BE) Scale. This scale consists of three subscales: BE-appearance, BE-attribution, and BE-weight (Mendelson et al., 2001). It helps identify the department an individual is most self-conscious about. Another commonly used measure for body-esteem involves participants identifying positive and negative body attributes through the viewing of pictures. Studies that use this method instruct participants to select the picture that best represents their body. If an individual is uncomfortable with his or her weight, he or she might begin to seek dangerous eating behaviors, like starvation or uncontrolled eating. Loren Gianini and Jane Smith (2007) conducted a study to examine how eating behavior related to self-esteem. There was a negative correlation between self-esteem and restraint eating behavior (Gianini & Smith, 2007). Low self-esteem scores and restraint eating were caused by unhappiness with one's body (Gianini & Smith, 2007).

De la Rie et al. (2005) found a relationship between self-esteem and quality of life: as self-esteem went down, so did qualify of life. It is crucial to study self-esteem because it has a heavy influence on the way a person chooses to live his or her life and how the person allows others to affect his or her emotional well-being. If guidance is provided at an early age to those who struggle with this, it could encourage positive self-perception. Body image satisfaction is often interchanged with self-esteem. Although

these are both related to feelings about oneself, they are different. Body image satisfaction relates to the self's perception of one's body and how it looks, and self-esteem is more about general feelings of self-worth and abilities (Jónsdóttir, Arnarson, & Smári, 2008). Self-esteem was measured using a separate questionnaire: Rosenberg's Self-Esteem Scale is one popular instrument used to determine self-esteem. This reliable and frequently used measurement tool consists of 10 questions used to determine one's feelings towards oneself.

Both men and women deal with low self-esteem and body satisfaction. One thing that contributes to this research problem is *gender differences.* To society, men and women are completely different. There are personality traits and struggles deemed either masculine or feminine. Men are labeled as weak if they are phased by the feminine concepts of self-esteem and body-esteem. Ignoring the male population in these matters is detrimental to their health. Men do struggle with these issues, and it is harder to detect because of how they respond. Instead of losing weight, men might use body enhancement substances to increase muscle mass. Roberto Olivardia et al. (2004) conducted a study to find variables that encourage men to use steroids and other body enhancing substances. In the results, self-esteem had a significantly negative correlation with body satisfaction; men who lacked in these departments used body enhancement substances to make up for it (Olivardia et al., 2004). As self-esteem increased, body dissatisfaction decreased and vice versa.

This study investigated the relationship between self-perception and eating behavior. Both males and females were selected to participate in hopes of distinguishing any differences. Exploring eating behaviors, self-esteem, and body-esteem could help researchers identify risk factors that cause eating disorders, suicide, and depression. The purpose of this study was to gain a better understanding of risk factors that influence mental health and eating disorders.

Methods

Participants

A total of 66 people between the ages of 18-25 participated in the study. The age restriction was implemented to identify findings related to traditional college-aged students. The college student population was targeted because it was the most readily available subject pool. Participants were recruited through the Wichita State University SONA system and face-to-face on campus.

Materials

A 56-item survey was created using Google Forms to investigate how self-perception is influenced by eating behavior. This survey included demographic questions to gain a description of the participant demographics and three questionnaires regarding self-esteem, body-esteem, and eating behavior. The Rosenberg's Self-Esteem scale was used to determine how positive or negative participants felt about themselves. Mendelson's Body-Esteem questionnaire was included as a measurement instrument for feelings about one's body. It contains three subscales: BE-appearance, BE-attribution, and BE-weight. The last portion of the survey was The Three-Factor Eating Questionnaire to measure eating behavior, which determines what type of eating tendencies an individual has (cognitive restraint, uncontrolled eating, and emotional eating).

Procedure

Regardless of recruitment method, all participants completed the 15-minute survey via Google Forms. Those who were initiated through SONA received one credit hour for their participation.

Results

Gender Differences

A series of independent sample t-tests were conducted to evaluate gender differences among self-esteem, body-esteem, and eating behavior. Males and females did not differ in self-esteem t

(56) = .93, p > .05 and body-esteem t (54) = -.29, p > .05. However, there was a significant gender difference with eating behavior (57) = 2.49 p < .01 (Figure. 1).

Table 1 Gender Means and Standard Deviations		
Questionnaire	Males	Females
Self-Esteem	19.44	20.06
	(6.33)	(6.87)
Body-Esteem	45.61	45.19
	(5.83)	(5.31)
BE-Appearance	25.21	25.20
	(3.41)	(3.48)
BE-Attribution	9.43	9.13
	(2.95)	(2.47)
BE-Weight	10.55	10.79
	(2.01)	(2.40)
TFEQ-R18	37.59	42.81
	(7.15)	(8.76)
Cognitive Restraint	12.52	13.50
	(2.97)	(3.48)
Uncontrolled Eating	17.55	19.68
	(3.68)	(5.33)
Emotional Eating	5.73	7.54
	(2.18)	(2.97)

Note. Standard deviations are shown in parenthesis.

Figure 1. Gender Differences with Eating Behavior. The figure presents the means between genders.

Relationship between Self-Esteem, Body-Esteem, and Eating Behavior

Pearson's correlation of coefficients was computed to test the relationship between self-perception and eating behavior. Sample size did vary based on the number of complete responses to each questionnaire. The overall scores on each questionnaire and their subscales were compared.

There was no significant relationship between the Body-Esteem Scale and Self-Esteem Scale, r (49) = -.06, p > .05 or with the TFEQ-R18, r (49) = -.26, p > .05. The Self-Esteem Scale and the TFEQ-R18 (Figure 2) had a statistically significant correlation of r (54) = .32, p<.05. As self-esteem scores increased, indicating lower self-esteem, more people tended to report poor eating habits. The results signify that individuals with low self-esteem tended to have unhealthy eating habits.
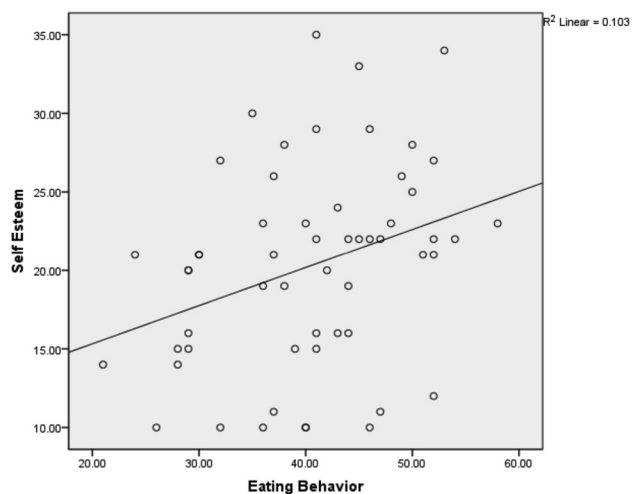

Figure 2. The correlation between the Self-Esteem Scale and the TFEQ-R18.

Within the TFEQ-R18 scale, emotional eating behavior and uncontrolled eating behavior showed a significant correlation (Figure 3.), r (59) = .67, p < .01. As emotional eating tendencies increased, so did uncontrolled eating behavior.
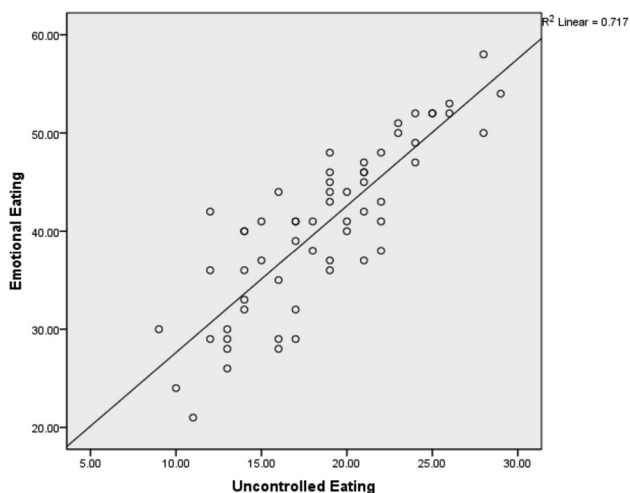
Figure 3. The relationship between Emotional Eating subscale and Uncontrolled Eating.

Figure 5. The relationship between BE-attribution subscale and Self-Esteem Scale.

Feelings about one's appearance and weight showed a positive relationship. When individuals felt good about their appearance, they seemed to be happier with their weight. BE-appearance and BE-weight (Figure 4) had a correlation of, r (61) = .36, p<.01.
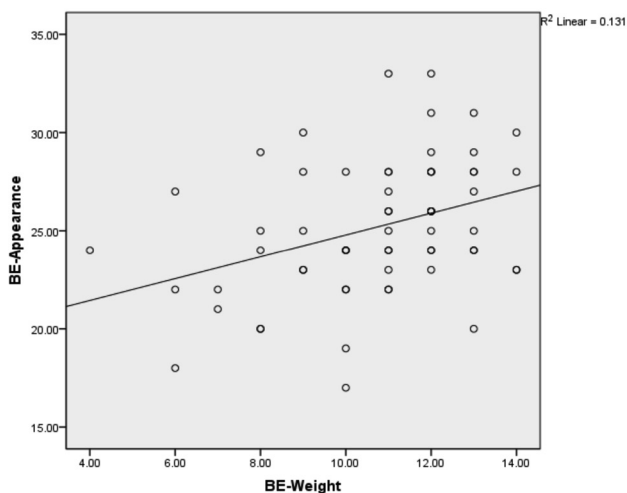

Figure 4. The relationship between BE-appearance subscale and BE-weight subscale.

Self-esteem and BE-attribution (Figure 5) showed a strong relationship with each other, r (51) = -.42, p<.01. Individuals who thought others held negative thoughts towards them were more likely to exhibit low self-esteem.
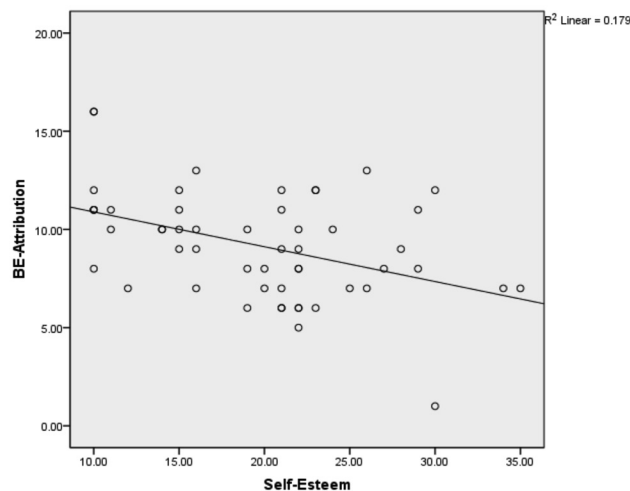
Discussion

Major Findings

Statistically significant gender difference was found in the TFEQ-R18. Women reported higher scores than males. Women are often body shamed in the media, which could explain the eating behavior findings. It could be that this pressures women to respond with unhealthy eating habits. Individuals who scored high in the Self-Esteem Scale, also scored high in the TFEQ-18. This means that people who struggled with positive self-esteem found it difficult to incorporate healthy eating behavior. Lacking positive feelings towards the self could discourage people from taking care of themselves and results in poor eating habits. Individuals expressed more positive feelings towards their appearance when they were happy with their weight. This can be referred back to the scores between BE-appearance and BE-weight. Weight is arguably the most relevant quality when it comes to beauty and, therefore, could play an important role in feelings towards an individual's appearance. After all, the Merriam-Webster dictionary defines beauty as "the quality of being physically attractive" (Merriam-Webster Dictionaries, 2016). People who reported low self-esteem also believed others viewed them poorly. This was gathered through the BE-attribution subscale and

Self-Esteem scale. Low self-esteem might prevent individuals from thinking others view them differently than how they feel about themselves. Emotional eating behavior increased as uncontrolled eating behavior increased. This could mean that emotional eaters lack a sense of self-control. These results show that self-esteem, eating behavior, and body-esteem contain relationships that may be risk factors to eating disorders and depression.

Limitations

Restricting the population to students 18-25 years old at Wichita State limits generalizability because what is applicable to Wichita State students might differ from people outside of campus. It is also important to note that this study excluded nontraditional students—those who are above the age of 25 and attending college; therefore, results from this study may not represent that population well. Older generations attending college could be affected differently when struggling with eating habits and self-perception. An older individual's response to negative self-perception could differ from younger populations. For example, adolescents who suffer from depression are more likely than adults to commit suicide (Jóndóttir et al., 2008). An additional weakness to this study would be the lack of diversity within the sample size. The majority of participants were Caucasian and female which could have had an impact on the results of this study.

To increase generalizability, more males should be recruited in order to have an equal amount of females and males to compare. It would have been beneficial to add family background questions to the study. This would help determine if family background has any connection with self-perception and eating behavior of individuals. Health history is another variable that could be taken into account in this study. For example, an individual's depres-

sion history may affect how he or she responds to the self-esteem, body-esteem, and eating behavior questionnaires. Moreover, recruiting participants in different stages of life would allow researchers to investigate how each demographic differs.

Future Research

Future research with self-perception and eating behavior is needed to gain a clearer understanding of risk factors associated with unhealthy life decisions. Determining risk factors can help create interventions aimed at preventing eating disorders and suicide. Including family background knowledge should also be included in future research. Family background could influence how a person develops self-esteem or body-esteem.

Conclusion

Society puts an extreme amount of value on beauty and has created standards that can be hard to follow. Due to human nature, people are bound to compare themselves to these standards. People may resort to unhealthy methods such as starvation, in hopes of achieving the impossible ideal body-image. Self-perception helps dictate the way people live their lives. It is important for more studies to look into self-esteem, body-esteem, and eating behavior habits. Gaining a clearer understanding of three variables can help reduce eating disorders, negative self-image, and suicide rates. In future studies, increased attention should be placed on studying the male population. Both genders are affected by the ideal body image society creates. Understanding self-esteem, body-esteem and eating behavior could help detect individuals who are at risk for mental health issues and eating disorders, which might encourage the creation and implementation of prevention programs in school systems.

References

Anglé, S., Engblom, J., Eriksson, T., Kautiainen, S., Saha, M. T., Lindfors, P. & Rimpelä, A. (2009). Three-Factor eating questionnaire-R18 as a measure of cognitive restraint, uncontrolled eating and emotional eating in a sample of young Finnish females. *International Journal of Behavioral Nutrition and Physical Activity*, *6*(1), 1.

Beauty. (n.d.). In *Merriam-Webster Online.* Retrieved from http://www.merriamWebster.com/dictionary/beauty

Christine, R. (2014, March 19). The Average Woman Vs. The Average Model. Retrieved June 5, 2016, from http://thoughtfulwomen.org/2014/03/19/average-woman-vs-average-model/

De la Rie, S. M., G. Noordenbos, & Van Furth, E. F. (2005). Quality of life and eating disorders. *Quality of Life Research, 14*(6), 1511-1521.

Etcoff, N., Orbach, S., Scott, J., & D'Agostino, H. (2004). The real truth about beauty: A global report. *Retrieved April, 15*, 2008.

Gianini, L. M., & Smith, J. E. (2007). Body dissatisfaction mediates the relationship between self-esteem and restrained eating in female undergraduates. *International Journal of Behavioral Consultation and Therapy, 4*(1), 48.

Hautala, L. A., Junnila, J., Helenius, H., Väänänen, A. M., Liuksila, P. R., Räihä, H. & Saarijärvi, S. (2008). Towards understanding gender differences in disordered eating among adolescents. *Journal of clinical nursing*, *17*(13), 1803-1813.

Jónsdóttir, S. R., Arnarson, E. Ö., & Smári, J. (2008). Body esteem, perceived competence and depression in Icelandic adolescents. *Nordic Psychology 60*(1), 58.

Kling, K. C., Hyde, J. S., Showers, C. J., & Buswell, B. N. (1999). Gender differences in self-esteem: a meta-analysis. *Psychological bulletin*, *125*(4), 470.

Mendelson, B. K., Mendelson, M. J., & White, D. R. (1997). Body-Esteem Scale for Adolescents and Adults. *Psyctests*, doi: 10.1037/t00047-000

Mendelson, B. K., Mendelson, M. J., & White, D. R. (2001). Body-esteem scale for adolescents and adults. *Journal of personality assessment*, *76*(1), 90-106.

Olivardia, Roberto, et al. (2004). Biceps and Body Image: The Relationship Between Muscularity and Self-Esteem, Depression, and Eating Disorder Symptoms. *Psychology of men & masculinity 5*(2), 112.

Rosenberg, M. (1965). Rosenberg Self-Esteem Scale. *Psyctests*, doi:10.1037/t01038-000

Health Information-Seeking Behaviors Among Preconceptional Women

Anna M. Wray
McNair Scholar, Wichita State University

Kyrah K. Brown, PhD
Sedgwick County Health Department
Public Health Performance Division

J'Vonnah Maryman, MPH
Sedgwick County Health Department
Public Health Performance Division

Sugantha Yuvaraj, MBBS
University of Kansas School of Medicine-Wichita

Tracie Collins, MD, MPH
University of Kansas School of Medicine-Wichita
Department of Preventive Medicine and Public Health

Abstract

The goal of preconception care is to optimize women's health prior to pregnancy. Barriers to obtaining preconception healthcare information may encourage women to turn to more informal sources of health information to make decisions about their health. The present study examined women's preconception health information-seeking behaviors. Four focus groups were conducted with 21 reproductive age women in Kansas. Focus group transcripts were themed and coded using the Coding Analysis Toolkit to distinguish preconception health information-seeking behaviors. Content analysis was used to examine preconception health information-seeking behaviors. It was found that women used active and passive health information seeking to get health information from family and friends, the internet, and other media sources. Among active-seeking participants, use of informal sources was influenced by contextual factors such as health care costs. Altogether, efforts to improve access to preconception health information have important implications for women's health and pregnancy outcomes. Our findings can inform the ongoing develop-

ment of preconception information-sharing strategies that incorporate women's informal networks. Furthermore, due to the towering need for public awareness and credible knowledge in preconception care, public health professions need to consider internet-based health promotion initiatives and interventions to increase women's use of preconception care.

Keywords: preconception health, health communication, health information-seeking behaviors, infant mortality

Health Information-Seeking Behaviors among Preconceptional Women

In the United States, infant mortality has been on a gradual decline over the last decade. Despite this decline, significant racial and ethnic disparities persist. For example, the infant mortality rate for non-Hispanic Blacks is more than two times higher than that for non-Hispanic Whites (Mathews, Mac-Dorman, & Thomas, 2015). Over the years, there has been a paradigm shift in maternal and child health that has led to an increased focus on improving women's preconception health and care to prevent poor birth outcomes. Preconception healthcare refers to a set of interventions aimed to increase healthy behaviors in women prior to a first or subsequent pregnancy and prevent poor birth outcomes (Johnson et al., 2006). Preconception healthcare includes services such as regular wellness check-ups, smoking and alcohol cessation, and social and mental health intervention (Johnson et al., 2006). Growing empirical evidence has demonstrated the effectiveness of preconception care in modifying behavioral, medical, and other health risks that impact birth outcomes (Shannon, Alberg, Nacul, & Pashayan, 2014; Wahabi, Alzeidan, Bawazeer, Alansari, & Esmaeil, 2010). Routine preconception healthcare is important considering that nearly half of all pregnancies are unintended (Finder & Zolna, 2014), and the sensitive period of fetal neural tube development to teratogenic agents is within the first three to four weeks of pregnancy (Rice & Barone, 2000). It is during this period of time that a woman may not even realize she is pregnant.

One challenge to the promotion of precon-ception health and care utilization is that there is a widespread lack of knowledge about the topic among women (McCorry, Hughes, Spence, Holmes, & Harper, 2012). Healthcare providers were not knowledgeable regarding the provision of information related to preconception health or may have lacked the time during a busy exam schedule (Curtis, Abelman, Schulkin, Williams, & Fassett, 2006; McCorry et al., 2012) has been cited as being associated with women's lack of knowledge. Previous research has shown that when there is a lack of information provided by clinical sources (e.g., doctors, health care professionals), women may seek out non-clinical sources of health information or use their own judgment to make health decisions (Wathen, 2006; Warner & Procaccino, 2004).

Health Information-Seeking Behaviors

The literature on health information-seeking behaviors (HISBs) has contributed to a broad understanding of the types of information being sought and the reasons for engagement in HISBs across various patient populations. Whereas HISBs have been widely investigated within the 'disease and illness context,' there has also been a focus within the context of preventive health and behaviors (Lambert & Loiselle, 2007; Weaver et al., 2010). Relatively few studies have explicitly focused on preconception health or healthcare. An overview of literature on informal health information sources and health seeking as it relates to preconception care is provided.

Informal Health Information Sources

Informal health information sources can be divided into two categories: interpersonal sources such as family, friends, or other lay persons and mass media sources such as television commercials, newspaper and magazine articles, and the Internet. Previous research indicates that women's decisions to use preconception care are typically influenced by friends and family (Squiers et al., 2013), partners (Canady et al., 2008; Temel et al., 2013), and other close individuals such as neighbors (Squiers et al., 2013). Moreover, women, especially ethnic minorities, use the following sources to obtain information about preconception health or healthcare: the Internet (e.g., medical websites) (Agricola et al., 2014; Agricola et al., 2013); social media sites (Dixon-Gray, Mobley, McFarlane, & Rosenberg, 2013); radio, including radio novellas (Dixon-Gray et al., 2013); and television commercials and programming (Dixon-Gray et al., 2013; Squiers et al., 2013).

Health Information Seeking

Health information seeking entails using specific strategies to acquire relevant information and has been shown to influence the way people make decisions about their health behaviors and their healthcare (Lambert & Loiselle, 2007). Several studies have identified two health information-seeking strategies: active seeking and passive seeking. Active seeking entails seeking out health information from media sources (the Internet, medical books, other media) or interpersonal sources (family, friends, other lay persons) (Wolff et al., 2010; Carlsson, 2000). In contrast, passive seeking entails receiving information that happens to come across via media sources, friends, or family members (Wolff et al., 2010; Carlsson, 2000). In this case, passive seekers may rely on information that is primarily elicited by other sources (Ramirez, Walther, Burgoon, & Sunnafrank, 2002). One earlier study inves-

tigating health information-seeking strategies among preconception women found that the frequency of actively seeking out nutrition-related information was lowest among preconception women compared to pregnant women (Szwajcer, Hiddink, Maas, Koelen, & van Woerkum, 2008). Several other studies examining health seeking among women suggest active-seeking behaviors which were motivated by contextual factors such as distance from healthcare setting, confidence in provider's competence (Wathen & Harris, 2007; Harris & Wathen, 2006), dissatisfaction with information provided by a health care provider, and interest in being a more active participant in their health (Warner & Procaccino, 2004). These studies, however, were not explicitly focused on preconception healthcare or reproductive-age women.

There is a dearth of literature focused on understanding health information sources and health seeking as it relates to preconception health. An understanding of HISBs as they relate to making decisions about preconception health has important implications for existing efforts to optimize women's knowledge and use of preconception healthcare. Thus, the aim of the present study was to explore informal sources of health information, health information seeking, and how they influence women's decisions about preconception health and the use of preconception healthcare.

Methods

Design

This study was a secondary analysis of a larger sequential mixed-methods study that examined women's preconception healthcare utilization. The objective of the qualitative component of the larger study was to explore key factors related to preconception healthcare utilization among reproductive age women. Focus groups were chosen as the most appropriate methodology because they allow for a socially oriented environment in which participants feel safe sharing information about themselves. Also, focus groups allow for

interactions between participants that can yield insightful, more spontaneous responses (Krueger & Casey, 2000; Morgan, 1998).

Setting and Participant Recruitment. The present study was conducted in Sedgwick County, Kansas, a county that contributes to 22% of all infant death in the state of Kansas (Moser, Hunt, Oakley, Crawford, & Soap, 2015). In Sedgwick County, the 2010-2014 infant mortality rates are 7.2 infant deaths per 1,000 live births as compared to the rate of 6.4 in the state (Kansas Department of Health and Environment [KDHE], 2015). This region is also challenged by significant racial and ethnic disparities in infant mortality. Rates are highest among non-Hispanic Black women (16.2 infant deaths/1,000 live births), followed by Hispanic women (8.0 infant deaths/1,000 live births) and non-Hispanic White women (4.6 infant deaths /1,000 live births) (KDHE, 2015). Additionally, among adults with no personal doctor or health care provider in this region, 17.4% are women and 31% are adults between the ages 18-44 years (KDHE, 2014), which suggests there are a number of women who may not even be seeing a doctor who can provide preconception health information or care.

Women were recruited using flyers distributed in community and clinical settings and by sending flyers to Sedgwick County Health Depart ment community partners through email distribution lists. Prospective participants contacted the second author via telephone or email and were provided with detailed information about the nature of the study before being screened for eligibility. If women confirmed interest in participating, they were scheduled for a focus group meeting and mailed a confirmation letter immediately after the conversation.

Participants were purposively sampled based on the following criteria: (1) women between the ages 18-44 years, (2) residents of Sedgwick County, Kansas, (3) reported never being pregnant before (nulligravida), or (4) reported a history of pregnancy or birth. Women were not eligible to participate for the following reasons: (1) being pregnant at the time of the study, (2) reported being

in menopause, (3) reported having a hysterectomy or removal of ovaries, (4) reported being diagnosed as infertile. Preconception and interconception women were targeted for this study, and separate sets of focus groups were scheduled for women in each category. Data saturation is the point at which information emerges frequently during data collection and no new information emerges. The research team determined through the use of debriefing discussions and notes that saturation was reached after the second focus group for each group of women, which falls within what is considered to be adequate to reach saturation (Morgan, 1997).

Protection of Human Subjects. This study was approved by the Wichita Medical Research and Education Foundation's Institutional Review Board. Before participating in focus groups, participants received a voluntary participation statement and provided verbal consent. To protect participants' privacy and confidentiality, several steps were taken during data collection. First, the principal investigator (second author) was the only individual to schedule focus groups with participants and collect their contact information for scheduling. Second, at the start of each focus group, the facilitators opened with an ice-breaker activity that included having a discussion about group expectations and norms for the session. Third, any identifying information shared during the focus group was eliminated from the transcript record by the second author.

Procedure

At the start of each focus group, participants completed a short demographic questionnaire. Focus group sessions were conducted in a secured community meeting space at the Sedgwick County Health Department. Focus groups were audiotaped and lasted between 90 and 120 minutes. Focus groups were co-facilitated by the second and third authors, who are African American women with extensive experience facilitating focus groups in research and practice settings. At each focus group, one student research assistant (first and fourth

author) was present to take detailed notes using a structured note-taking template. Immediately after each focus group, the research team held debriefing sessions to discuss responses, note emerging themes, and identify areas of improvement. This process allowed for improvements in focus group planning and facilitation to promote richer discussion with participants. At the end of each focus group, participants were given a $20 Walmart gift card as a token of appreciation. Participants were also invited to sign-up to be contacted to return for a member-checking session.

Focus group questions were developed using Krueger's guidelines for semi-structured discussion guides (Krueger, 1998). The discussion guide included five guiding questions with probes to help participants clarify and elaborate on their experiences. Participants were asked to describe the following concepts: (1) what it means to be a healthy woman, (2) what comes to mind when they think of 'preconception care,' (3) the types of preconception care services that they've used in the past, (4) what things have made it easier to access or use those services, (5) what things have made it difficult to access or use those services, and (6) if they were in charge, what practices or policies would they change to ensure that women like them can access preconception care services.

Sample. Twenty-one preconception and interconception women participated in the study. Participants' ages ranged from 18 to 44, with the mean age being 31 years (SD = 7.63). The majority of participants were preconception women (N=12, 57%). Participant demographic characteristics are provided in Table 1.

Data Management and Analysis. Focus groups were transcribed by a professional transcriptionist. In this study, data was entered and managed using the Coding Analysis Toolkit Software. For this study, a directed content analysis approach was used to analyze the data. Directed content analysis is appropriate to use when there is existing research on a phenomenon that would benefit from further exploration (Hsieh & Shannon, 2005). To begin, the first author used the

Table 1
Participant Demographic Characteristics

Variable	All Women (N=21)
Employment Status	
Self-employed	1 (5%)
Full-time	11 (52%)
Part-time	5 (24%)
Unemployed	4 (19%)
College Status	
Yes	9 (43%)
No	12 (57%)
Level of Education	
High School Diploma	1 (5%)
Some College	6 (29%)
Associates	4 (19%)
Bachelors	6 (29%)
Masters	4 (19%)
Race/Ethnicity	
White/Caucasian	5 (24%)
Black/African American	10 (48%)
American Indian/Alaska Native	1 (5%)
Bi-Racial or Multi-Racial	3 (14%)
Other	2 (10%)
English Primary Language	
Yes	18 (86%)
No	1 (5%)
Source of Health Coverage	
None	2 (10%)
Health Insurance/Job	9 (43%)
Health Insurance/Paid by others	6 (29%)
State Insured	1 (5%)
TRICARE/Military Health Insurance	1 (5%)
Other	2 (10%)
Annual Household Income	
Less than $24,999	5 (24%)
$25,000 - $49,999	11 (52%)
$50,000 - $79,999	2 (10%)
More than $80,000	3 (14%)
Marital Status	
Single/Never Married	12 (57%)
Married/Committed Domestic Partnership	6 (29%)
Divorced/Separated	3 (14%)

existing literature on informal health information sources to develop and define codes. Next, the first and second author separately read each transcript carefully two times before beginning the coding process. Any textual data that could not be coded using the pre-identified codes were set aside for later to determine if they represented new categories. After the independent coding process, the authors review each code and its associated textual data to determine if the data supported the code description. The authors also discussed any new themes that emerged from the textual data that was set aside earlier. Two relevant themes emerged and were retained. Additionally, the authors discussed discrepancies and disagreements to reach consensus on final coded data.

Trustworthiness. Several steps were taken to ensure the trustworthiness of the data. To ensure dependability of the data, the authors used several sources of data (transcripts, detailed notes, and debriefing notes) to ensure a comprehensive understanding and maintained an open dialogue during data analysis. Credibility was ensured through an inter-coder agreement process and using quotations that illustrate the study's findings. To achieve transferability of the data to other populations of women, we described the contextual background of the setting from which participants were recruited and participants socio-demographic characteristics. Finally, we obtained respondent validation through the member-check process. Ten participants returned to verify the findings by reading a summary report and confirmed its accuracy in reflecting their experiences.

Results

Figure 1 shows key themes regarding participants' use of informal information sources and health-seeking strategies as it relates to preconception health and care. In addition, three contextual factors that influenced participants' health information seeking are depicted in this figure. Each theme presented in Figure 1 will be discussed below.
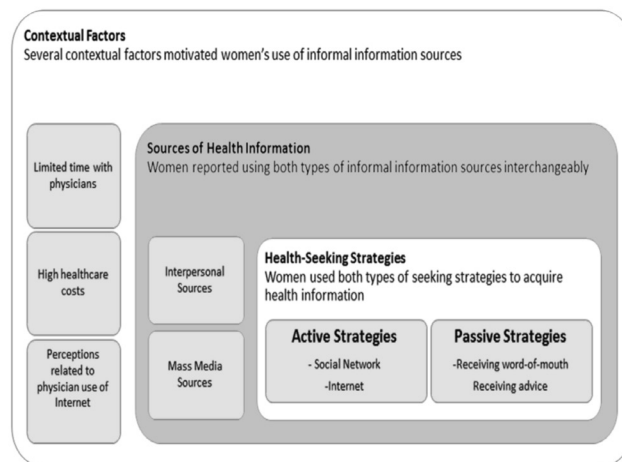

Figure 1. Contextual, Health Information, and Health-Seeking Strategies Results. This figure illustrates Contextual Factors and Information Sources.

Health Information Sources: Interpersonal Sources

The women in the study emphasized the important role that friends and family members played in providing health information. Family members and friends, who were mostly women, provided information or advice on issues such as health symptoms, family planning options and resources, community-based health resources, well-woman care, interconception care resources, and even shared recommendations about doctors or services. Most women reported that their mothers were key sources of health information about health behaviors and care utilization. Participants described having open and supportive relationships with their mothers. One woman stated, "I get a lot from my mom, too…She knows a lot of that and so I get all of my stuff from her."

Moreover, the majority of women described other female family members, such as aunts, from whom they acquired knowledge about health matters or health resources in the community. The women viewed their female family members as trusting and knowledgeable about health or care options. One woman explained that it was important to her to "have family who are knowledgeable about it

[preconception health behaviors]." In addition, participants' family members helped them navigate the health care system. As one woman explained,

"I just think having family that have the knowledge to tell me if I ask. That's the key. [When I ask they] say, 'Oh you go here or ask about this, talk to this person...'"

Women, particularly younger participants, indicated that their friends provided them with information about health and provide advice that helps them make preconception care choices. Some of these women did not necessarily have open relationships with their mothers and thus were not comfortable talking with them about contraception. One participant explained,

"[I found out information by] listening to everybody else. It's kind of sad, but it seems to be difficult to find it [information about preconception health and preconception care] in other places. For me, when I was in high school, I never had a pap smear. I didn't want my mom to know I was having sex. I knew I needed to get on birth control and so that is when I was going to the clinics and that was from [my] friends telling me."

Another woman, who was a college student, described an experience which involved a friend explaining the importance of a well-woman check-up and urging her to go get one. According to the participant, she "had never had one before" and was not aware that she needed it. She continued by saying that as a result of her friend she has a better understanding about how "to be aware of what is going on with my body."

According to some women, although friends played an influential role in their health care decisions, there were challenges in relying on their friends' advice. The majority of the women agreed with this sentiment, but maintained that their friends' advice was still valuable. One women provided an example based on going to get dental care to describe the challenge of relying on a friend's advice:

"So you ask, 'Hey best friend, how was it?'

They say 'It's terrible.' So, it's going to make you scared and not want to go. It might not have been [that] bad, but I wouldn't know that because I will never get to go because I have a negative opinion from someone else."

Mass Media Sources

Our analyses revealed that participants used various forms of media to acquire information about preconception care or to make health care decisions. The majority of women indicated that they used the Internet regularly (i.e., Google, social media sites) to obtain health-related information. Participants viewed the Internet as an easy and efficient way to acquire information about their health. For example, one woman stated that she "uses Google for everything." Other media sources included television commercials and home remedy books or references.

The women talked at length about the motivating factors for their use of media sources. The first motivating factor was limited time with their primary health care provider (if they had one). Several participants explained that they felt there was never enough time to ask their doctors health questions. They shared experiences of being "rushed" or "brushed off like you are asking too many questions." Consequently, the women turn to the Internet to answer some of their health-related questions. In response to the ongoing discussion about the challenges with providers, one woman stated,

"We have to be responsible to an extent and be able to advocate for ourselves. I also feel that we need to be able to learn to be a consumer for ourselves so, if you have something going on [with your health], if you have access to the Internet, Google it! You can Google anything. Try to get some knowledge and understanding for yourself."

A second major motivator was the high cost of healthcare services. The women described in detail

their financial concerns and how the cost of health care often delayed or deterred them from scheduling a doctor's appointment. One woman indicated that when she is faced with a health problem, she uses the Internet in lieu of visiting a physician, "I will Google a natural healing process, anything, so I can keep the money in my pocket and not have to worry about that bill."

Other participants also described their disdain for physicians using time during their visits to retrieve health information from the Internet. Women reported that they did not feel they should pay for their visit, and felt that they could have simply accessed the information on their own. For example, one participant stated, "When you go to the doctor's office…and they pull out their phone and they're getting on WebMD or Google or whatever they're doing…and I'm like why am I not at home doing this?"

Health-Seeking Strategy

Our analyses revealed that the women in this study used both active and passive health information seeking strategies. In terms of active health-seeking, women described various occasions in which they actively sought out information from their family members and friends. For example, some participants asked general questions related to health and health behaviors and others asked family members for information about accessing available health resources or services. Moreover, participants employed active health-seeking approaches to making decisions by seeking out information through the Internet and other media channels. As mentioned, participants' motives for using the Internet, for example, to acquire information included limited time with physicians and healthcare costs.

There were situations in which informal sources elicited health-related information or advice, which then influenced women's decisions. For example, among the participants who indicated that their mothers were key information sources, many reported their mothers were the

impetus behind their decisions to access health care services. There were also instances where participants relied on word-of-mouth or ongoing conversations among peers or friends to gather information to make health decisions. Few women, however, described passively receiving information through media sources such as social media or television commercials.

Discussion

Our findings reveal that family and friends, as well as media sources, play a key role in women's decisions regarding preconception health and healthcare. In particular, younger women tended to rely on their close friends to acquire information for making health decision. These findings support previous reports that have cited the importance of social support in influencing women's choices to engage in preconception healthcare through upbringing, advice, and suggestions (Dixon-Gray, Mobley, McFarlane, & Rosenberg, 2013; Upadhyay, Liabsuetrakul, & Shrestha, 2014; Temel et al., 2013). As expected, the most cited media source that women used to acquire information about preconception health issues was the Internet. This is consistent with recent work revealing that almost half of all women frequently use the Internet for health-related information (Agricola et al., 2014).

Several studies focused on women have reported distance from healthcare setting, lack of confidence in provider's competence (Wathen & Harris, 2007; Harris & Wathen, 2006), and dissatisfaction provided by health care provider (Warner & Procaccino, 2004) as reasons for seeking out informal information sources. Our findings contribute to the literature by providing evidence that among reproductive-age women high healthcare costs and limited time with physicians, specifically, are two key reasons why health information was sought out using Internet and other informal sources.

Moreover, our findings also indicate that participants' use of active- vs. passive-information seeking to acquire knowledge and make health decisions was situational. In most cases, an active information-

seeking strategy was used to obtain information from individuals in their social network or using media sources. In other situations, close friends or family volunteered unsolicited information or advice which the women used to make decisions about health care or preconception care.

In summary, informal health information sources and health information-seeking behaviors were highlighted among the sample of reproductive age women. Specifically, public health professionals should consider Internet-based health promotion initiatives to reach large, diverse groups of reproductive age women, especially younger women, in an effort to provide adequate information related to preconception care. Internet-based interventions are relatively inexpensive, convenient and offer autonomy and anonymity for women seeking information that may be sensitive or stigmatizing (Bailey et al., 2013). In general, health promotion interventions should also focus on incorporating individuals within women's social networks because they play such an influential role in their health care and preconception care decision making. Although the Internet is one of the most common ways to obtain health information, Agricola and colleagues (2013) found that the majority of preconception information found on the Internet is not consistent with international preconception health clinical recommendations. Thus, public health strategies aimed at improving preconception health information on the Internet may also be beneficial for women and health professionals (Agricola et al., 2013).

The present study supports previous research suggesting that women seek out informal health information sources particularly when they feel they have not obtained adequate information from providers. Given the reality of time constraints in medical offices, health care professionals should explore strategies that help maximize information sharing before, during or after the clinical visit. For example, patient portals that allow patients to interact and communicate with providers may be a practical approach. Furthermore, our findings, in part, show that access to healthcare is not enough. At the policy level, the present study has implications for women's access to affordable preconception care as well as health care in general. The majority of women in this study were insured and college graduates, yet the high out-of-pocket health care expenses was a major deterrent for them. The expansion of women's access to affordable health care remains a fundamental health policy priority for ensuring optimal preconception health.

Several limitations need to be considered in this study. First, this was a secondary analysis which made it impossible to ask partici-pants additional follow-up questions related to their health-seeking behaviors. Common methodological challenges in secondary qualitative analyses are related to the extent to which data generated from the original study are amendable to a secondary analysis and the extent to which the purpose of the secondary analysis differs from that of the original study (Hinds, Vogel, & Clarke-Steffen, 1997). Considering that there were no issues related to missing data sources, the research questions were closely related to that of the original study, and data of appropriate depth and detail were obtained (Hinds et al., 1997), we determined that valid information resulted from this secondary analysis. However, future investigations should explore, in more detail, women's health information-seeking as it relates to preconception care. A second limitation is that the small sample size limits the generalizability of our findings to all reproductive age women. However, within qualitative research, a sample of 21 women is considered adequate for generating rich, detailed descriptions of participants' experiences. Our findings may be transferable, however, to other populations representative of similar demographic and contextual backgrounds.

Conclusion

Women use multiple health information-seeking strategies to help them make decisions related to their health and preconception care. Informal health information sources such as family and

friends or the Internet play an especially important role in women's health decisions. Moreover, women's active-seeking is motivated by contextual factors such as limited time with and information from physicians and high health care costs. Furthermore, public health professions should consider Internet-based health promotion initiatives and interventions that increase knowledge of preconception care among women and others within their social networks. In addition, health care professionals might consider finding ways to ensure adequate preconception health information sharing with patients. For example, access to accurate health information may be increased using online patient portals. It may also be important to understand their patients' attitudes towards physician use of the Internet to retrieve health information during clinical consultations. Finally, health professionals and policy-makers should understand the implications of high health care costs as it relates to women's use of informal health information. Moreover, affordable access to preconception care will be important in ensuring optimal preconception health among reproductive-age women.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

References

Agricola, E., Gesualdo, F., Pandolfi, E., Gonfiantini, M. V., Carloni, E., Mastroiacovo, P., & Tozzi, A. E. (2013). Does googling for preconception care result in information consistent with international guidelines: A comparison of information found by Italian women of childbearing age and health professionals. *BMC Medical Informatics and Decision Making, 13*(1), 14.

Agricola, E., Pandolfi, E., Gonfiantini, M. V., Gesualdo, F., Romano, M., Carloni, E., Tozzi, A. E. (2014). A cohort study of a tailored web intervention for preconception care. *BMC Medical Informatics & Decision Making*, *14*(1), 1–25. http://doi.org/10.1186/1472-6947-14-33

Bailey, J.V., French, R., Murray, E., Pavlou, M., Copas, A., McCarthy, O. Carswell, K., Rait, G., Hart, G., Nazareth, I., Free, C., French, R., & Murray, E. (2013). The Sexunzipped trial: optimizing the design of online randomized controlled trials. *Journal of Medical Internet Research, 15*(12), e278.

Brown, J. B., Carroll, J., Boon, H., & Marmoreo, J. (2002). Women's decision-making about their health care: Views over the life cycle. *Patient Education and Counseling, 48*(3), 225-231.

Canady, R. B., Tiedje, L. B., & Lauber, C. (2008). Preconception care & pregnancy planning: voices of African American women. *MCN: The American Journal of Maternal/Child Nursing, 33*(2), 90-97.

Carlsson, M. (2000). Cancer patients seeking information from sources outside the health care system. *Supportive Care in Cancer*, *8*(6), 453-457.

Curtis, M., Abelman, S., Schulkin, J., Williams, J. L., Fassett, E. M. (2006). Do we practice what we preach? A review of actual clinical practice with regards to preconception care guidelines. *Maternal and Child Health Journal*, *10*, 53-58. DOI: 10.1007/s10995-006-0112-0

Dixon-Gray, L. A., Mobley, A., McFarlane, J. M., & Rosenberg, K. D. (2013). Amor y Salud (Love and Health): A Preconception Health Campaign for Second-Generation Latinas in Oregon. *American Journal of Health Promotion*, *27*(sp3), S74–S76. http://doi.org/10.4278/ajhp.120113-ARB-29

Dunlop, A. L., Logue, K. M., Thorne, C., & Badal, H. J. (2013). Change in Women's Knowledge of General and Personal Preconception Health Risks Following Targeted Brief Counseling in Publicly Funded Primary Care Settings. *American*

Journal of Health Promotion, 27(sp3), S50–S57. http://doi.org/10.4278/ajhp.120116-QUAN-39

Finder, L. B. & Zolna, M.R. (2014). Shifts in intended and unintended pregnancies in the United States 2001-2008. American Journal of Public Health, *104*(S1), S1-S48.

Harris, R. M. & Wathen, C. N. (2007). 'If my mother was alive I'd probably have called her.' Women's Search for Health Information in Rural Canada. *Reference and User Services Quarterly, 47,* 67-79.

Hinds, P.S., Vogel, R.J., & Clarke-Steffen, L. (1997). The possibilities and pitfalls of doing a secondary analysis of a qualitative data set. *Qualitative Health Research, 7*(3), 408-424.

Hsieh, H.F. & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15,* 1277-1288.

Hillemeier, M. M., Weisman, C.S., Chase, G.A., Dyer, A. M., & Shaffer, M. L. (2008). Women's Preconceptional health and use of health services: implications for preconception care. *Health Service Research, 43,* 54-75. doi:10.1111/j.1475-6773.2007.0074x

Johnson, K., Posner, S., Biermann, J., Cordero, J., Atrash, H., Parker, C., Boulet, S., & Curtis, M. (2006). Recommendations to improve preconception health and health care — United States: a report of the CDC/ATSDR Preconception Care Work Group and the Select Panel on Preconception Care. MMWR: Morbidity & Mortality Weekly Report, *55*(RR-6), 1–22.

Kansas Department of Health and Environment (2015). "Infant Mortality-Sedgwick County, 2014." Maternal and Infant Health Coalition. Wichita, KS. 19 November 2015. Presentation.

Kansas Department of Health and Environment (2014). 2013 Kansas Behavioral Risk Factor Surveillance System Local Data. Topeka, KS: Kansas Department of Health and Environment. Retrieved from http://www.kdheks.gov/brfss/BRFSS2013/Sedgwick.pdf

Krueger, R. A. (1998). Developing questions for focus groups: Focus Group Kit 3. Thousand Oaks, CA: Sage.

Krueger, R. A., & Casey, M. A. (2000). Focus groups:

A Practical Guide for Applied Researchers (4th edition). Thousand Oaks, CA: Sage.

Lambert, S. D., & Loiselle, C. G. (2007). Health information-seeking behavior. *Qualitative Health Research, 17*(8), 1006-1019.

Mathews, T. J., MacDorman, M.F., Thomas, M. E. (2015). Infant mortality statistics from the 2013 period linked birth/infant death data set. National Vital Statistics Reports, *64*(9). Retrieved from http://www.cdc.gov/nchs/data/nvsr/nvsr64/nvsr64_09.pdf

McCorry, N., Hughes, C., Spence, D., Holmes, V., & Harper, R. (2012). Pregnancy Planning and Diabetes: A Qualitative Exploration of Women's Attitudes Toward Preconception Care. *Journal of Midwifery & Women's Health, 57*(4), 396–402.

Morgan, D.L. (1997). Focus groups as qualitative research (2nd edition). Thousand Oaks, CA: Sage.

Morgan, D. L. (1998). The Focus group guidebook. Thousand Oaks, CA: Sage.

Mosier, S., Hunt, D.C., Saadi, E.W., Oakley, D., & Crawford, G. (2015). Selected special statistics stillbirths and infant deaths, Kansas [Research Summary], 2014. Kansas Department of Health and Environment, Topeka: Kansas. Retrieved from http://www.kdheks.gov/hci/IMR/2014_IMR_REPORT.pdf

Ramirez, A., Walther, J. B., Burgoon, J. K., & Sunnafrank, M. (2002). Information seeking strategies, uncertainty and computer-mediated communication: Towards a conceptual model. *Human Communication Research, 28*(2), 213-228.

Rice, D., & Barone, S. (2000). Critical periods of vulnerability for the developing nervous system: Evidence from humans and animal models. *Environmental Health Perspectives, 108,* 511-533.

Robbins, C. L., Zapata, L., B., Farr, S., L., Kroelinger, C., D., Morrow, B., Ahluwalia, I., Barfield, W., D. (2014). Core State Preconception Health Indicators — Pregnancy Risk Assessment Monitoring System and Behavioral Risk Factor Surveillance System, 2009. MMWR Surveillance Summaries, *63*(3), 1–62.

Shannon, G. D., Alberg, C., Nacul, L., & Pashayan, N. (2014). Preconception healthcare and congenital disorders: systematic review of the effectiveness of preconception care programs in the prevention of congenital disorders. *Maternal and Child Health Journal*, *18*(6), 1354-1379.

Spence, M., Alderdice, F. A., Harper, R., McCance, D. R., & Holmes, V. A. (2010). An exploration of knowledge and attitudes related to pre-pregnancy care in women with diabetes. *Diabetic Medicine*, *27*(12), 1385–1391. http://doi.org/10.1111/j.1464-5491.2010.03117.x

Squiers, L., Mitchell, E. W., Levis, D. M., Lynch, M., Dolina, S., Margolis, M., Kish-Doto, J. (2013). Consumers' Perceptions of Preconception Health. *American Journal of Health Promotion*, *27*, S10–S19.

Szwajcer, E. M., Hiddink, G. J., Maas, L., Koelen, M. A., & van Woerkum, C. M. J. (2008). Nutrition-related information-seeking behaviors of women trying to conceive and pregnant women: evidence for the life course perspective. Family Practice, *25*, i99-i104. doi: 10.1093/fampra/cmn077

Temel, S., Birnie, E., Sonneveld, H. M., Voorham, A. J. J., Bonsel, G. J., Steegers, E. a. P., & Denktaş, S. (2013). Determinants of the intention of preconception care use: Lessons from a multi-ethnic urban population in the Netherlands. *International Journal of Public Health*, 58(2), 295–304. http://doi.org/10.1007/s00038-012-0396-3

Wahabi, H. A., Alzeidan, R.A., Bawazeer, G.A., Alansari, L.A., & Esmaeil, S.A. (2010). Preconception care for diabetic women for improving maternal and fetal outcomes: A systematic review and meta-analysis. *BMC Pregnancy Childbirth, 10*(63). doi: 10.1186/1471-2393-10-63.

Wathen, C. N. (2006). Health information seeking in context: How women make decisions regarding hormone replacement therapy. *Journal of Health Communication*, *11*, 477-493.

Wathen, C. N. & Harris, R. M. (2007). "I try to take care of it myself." How rural women search for health information. Qualitative Health Research, *17*(5), 639-651.

Warner, D. & Procaccino, J. D. (2004). Toward wellness: Women seeking health information. *Journal of the American Society for Information Science and Technology*, *55*(8), 709-730.

Weaver, J. B., Mays, D., Weaver, S. S., Hopkins, G. L., Eroglu, D., & Bemhardt, J. M. (2010). Health Information-Seeking Behaviors, Health Indicators, and Health Risks. *American Journal of Public Health*, *100*, 1520-1525. doi:10.2105/AJPH.2009.180521

Wolff, L. S., Massett, H.A., Weber, D., Mockenhaupt, R. E., Hassmiller, S., & Maibach, W. (2010). Opportunities and barriers to disease prevention counseling in the primary care setting: A multisite qualitative study with US health consumers. *Health Promotion International*, *25*, 265-276.

Research Summaries

The Role of Skin Complexion on African American Emerging Adults

Alissa Bey

McNair Scholar, Wichita State University

Rhonda K. Lewis, PhD

Professor of Psychology

Summary

Skin-complexion discrimination is experienced by various races; however, African Americans experience colorism uniquely due to the wide array of skin complexions within their race. A steadily growing body of literature has been reporting on the issue of colorism in the African American community. Because colorism has been linked to various psychological and socio-economic outcomes in adulthood, it is important to seek information on colorism's individual and social role on members of the African American community in order to better understand it and deter any of its negative effects (Edwards, 1972; Hunter, 2013; Keith & Herring, 1991; Klonoff & Landrine, 2000; Veenstra, 2011).

Through the last few decades there has been a significant amount of research on colorism among African Americans (Maxwell, Brevard, Abram, & Belgrave, 2014; Monroe, 2013; Okazawa-Rey, Robinson, & Ward, 1986; Thompson, 2014). Kenneth and Maime Clark can be considered the pioneers of color discrimination research on African Americans. Their 1940's dolls study found evidence that African Americans begin to identify with others based on skin complexion as early as preschool. Pre-school aged children are also thought to identify having lighter skin as beneficial. In one famous study, African-American and Caucasian children were given a box with pictures of Caucasian children in it and a box with pictures of African-American children in it and asked to place their own picture in the box with the people they were most like. Only 19% of African-American children correctly identified with their race as compared to 77% of Caucasian children who correctly identified with their race (Katz & Kofkin, 1997). One explanation for this may be that African American individuals more often associate dark skin with negative qualities, such as undesirability and lack of intelligence, while light skin is often associated with more positive qualities, such as intelligence and beauty (Anderson & Cromwell, 1977; Hall, 1992). It is possible that because these children did not want to internalize these negative qualities, they placed their picture in the box that they recognized had more positive qualities. Future research is needed to explore color consciousness and internalized messages about skin-complexion for those in the African American community with light skin.

Rarely have researchers explored skin complexion qualitatively, leaving a gap in the literature regarding how people experience colorism and why skin complexion plays a role in social capital.

An exploratory perspective on skin complexion discrimination will allow researchers to uncover rich details on the impact that the phenomenon has on individuals and in what ways it exists in the everyday lives of African Americans. This study aimed to expand on past research by exploring the experiences of African American emerging adults and their perceptions on how skin complexion has shaped their lives. Exploring the role of skin complexion is important in order to diminish the social equity gap between various skin complexions and foster a better understanding of psychological well-being for individuals who are a part of the African American community.

In this study, a brief survey was used to gather information about the participants' well-being, self-perception of skin complexion, and satisfaction level with skin complexion. Two focus groups were conducted with African American college-aged emerging adults to explore participants' experiences regarding skin complexion during the time from youth to emerging adulthood. This study had six participants: two males and four females. Four participants identified as having dark skin, and two identified as having medium skin. After examining participants' responses, the following themes were found: family dynamics, skin complexion privileges, media, mate selection, and no skin complexion privileges. The overall themes were family dynamics and skin complexion privileges. The female specific themes were media and mate selection. The male specific theme was no skin complexion privileges.

Ultimately, there were similarities in themes for males and female as well as gender specific themes. Females were more concerned with media and mate selection than males, but both genders' concepts about skin complexion were influenced by family and both genders recognized skin complexion privileges in the African American community. Family dynamics played a role in the participants' concept of skin complexion. These dynamics encouraged first experiences with noticing skin complexion, developing a negative view of their skin complexion, or developing a positive view of their skin complexion. The participants also felt that certain skin complexions have specific privileges. For example, light skin was privileged in many ways, but those with dark skin seemed to be a more cohesive group in the African-American community. Females discussed how they felt that the media sent messages of who is beautiful by maintaining the majority of females with lighter skin in images of beauty, such as Rihanna and Beyoncé. The women also discussed the phenomenon of celebrity skin bleaching in the media. They did not agree with skin bleaching, but it attested to the social importance of having light skin. The women in the focus group discussed their feelings on mate selection playing a significant role in their insecurities about dark skin during their youth. They expressed that they felt that males were attracted to women with light skin. One of the males in the focus group discussed how he felt that skin complexion did not have an impact on social or economic factors because people can achieve anything based on their skills.

Critical Race theory can be used as a framework to understand these results. Many of these findings were congruent with past literature. Through this research we find that the family is an important institution where skin complexion dynamics are learned. Efforts should be made to educate African American parents about the effects of skin complexion on their children. This research also suggests an interesting occurrence in mate selection. While females reported colorism in mate selection, as they felt males were more attracted to women with light skin, the males did not express a skin complexion preference. Men may be unconscious of this bias because they are not affected by colorism in this way since females did not report a skin complexion preference in mate selection. Males' mate selection preferences may be influenced by the media, which was a major theme for women, as they stated media shows more women with light skin in positive attractive roles. The media may be an important institution in creating the idea that light skin is an important characteristic of beauty for Black women. More research is needed to

explore the development of skin complexion biases as well as the development of resilience. With the expansion of research on the role of skin complexion, we will be better able to meet the social and psychological needs of the African American community during emerging adulthood.

References

Anderson, C., & Cromwell, R. L. (1977). 'Black is beautiful' and the color preferences of Afro-American youth. *Journal Of Negro Education, 46*(1), 76-88. doi:10.2307/2966874

Clark, K. B., & Clark, M. K. (1940). Racial identification of negro preschool children. *Journal Of Social Psychology, 11*(1), 159-169.

Edwards, O. L. (1972). Skin color as a variable in racial attitudes of Black urbanites. *Journal of Black Studies, 3*, 473-483.

Hunter, M. (2013). The consequences of colorism. In R. E. Hall, R. E. Hall (Eds.), *The melanin millennium: Skin color as 21st century international discourse* (pp. 247-256). New York, NY, US: Springer Science + Business Media. doi: 10.1007/978-94-007-4608-4_16

Katz, P. A., & Kofkin, J. A. (1997). Race, gender, and young children. In S. S. Luthar, J. A. Burack, D. Cicchetti, J. R. Weisz, S. S. Luthar, J. A. Burack, … J. R. Weisz (Eds.), *Developmental psychopathology: Perspectives on adjustment, risk, and disorder* (pp. 51-74). New York, NY, US: Cambridge University Press.

Keith, V. M., & Herring, C. (1991). Skin tone and stratification in the Black community. *American Journal Of Sociology, 97*(3), 760-778. doi:10.1086/229819

Klonoff, E. A., & Landrine, H. (2000). Is skin color a marker for racial discrimination? Explaining the skin color–hypertension relationship. *Journal of behavioral medicine, 23*(4), 329-338.

Maxwell, M., Brevard, J., Abrams, J., & Belgrave, F. (2015). What's color got to do with it? Skin color, skin color satisfaction, racial identity, and internalized racism among African American college students. *Journal Of Black Psychology, 41*(5), 438-461. doi:10.1177/0095798414542299

Monroe, C. R. (2013). Colorizing educational research: African American life and schooling as an exemplar. *Educational Researcher, 42*(1), 9-19. doi:10.3102/0013189X12469998

Okazawa-Rey, M., Robinson, T., & Ward, J. V. (1986). Black women and the Politics of Skin Color and Hair. *Women's Studies Quarterly, 14*(1/2), 13-14.

Thompson, V. S. (2014). Fragmented identity: Psychological insecurity and colorism among African Americans. In K. J. Norwood (Ed.), *Color matters: Skin tone bias and the myth of a postracial America* (pp. 139-157). New York, NY, US: Routledge/Taylor & Francis Group.

Veenstra, G. (2011). Mismatched racial identities, colourism, and health in Toronto and Vancouver. *Social Science & Medicine, 73*(8), 1152-1162. doi:10.1016/j.socscimed.2011.07.030

Maximizing Grasping Power and Functionality of a Prosthetic Hand through an Active Palm Roll Joint

Jose Esquivel
McNair Scholar, Wichita State University

Yimesker Yihun, PhD
Assistant Professor of Mechanical Engineering

Summary

Amputations are serious Medical Procedures that affect a person's ability to perform everyday tasks, such as grasping. Nearly two million amputation patients in the USA can benefit from a prosthetic limb [1]. Various aspects direct the evolution and growth of the prosthetic hand, including functionality, mechanism to human interface, controllability, and aesthetic design. Functionality of the mechanism and its ability to accurately mimic the biology of the human body have become important focuses in the field of prosthetics [2-4].

Some of the most recent advanced prosthetic hands currently on the market include the BeBionic and the I-Limb. This study analyzed all the data collected from different design sources in order to discover faults involving functionality. After reviewing the different designs, there was a realization that each prosthesis did a poor job mimicking the anatomy of a human palm by not including any palm folds in the designs. Without the proper structural stability that the palm fold provides, grasping items like drinking cups can be troublesome, especially for patients who lack upper body strength. To address the problem, this study manipulated an already existing prosthetic hand model and 3D technology. By utilizing 3D printing and incorporating the palm roll and anatomical changes, a better prosthetic hand that maximizes grasping power while being less expensive can be created.

3D Printing

The cost of the BeBionic is around $11,000, and the cost of the I-Limb is around $38,000; therefore, they are cost prohibitive. One reason these products are expensive is the process by which they are manufactured. However, 3D printers can now create and produce structurally sound prototypes much quicker. This study utilized 3D technology and PLA plastic material in order to create a prosthetic hand that is more affordable, making the mechanism universal and available for everyone.

Anatomical Design

By incorporating the active palm roll and changing the finger design, the grasping power and stability of the prosthetic hand could be maximized. The modifications made to the preexisting prosthetic model design (Raptor Reloaded Prosthetic Hand created by E-nable [5]) were based on

the dimensions of the average male hand. These modifications were conducted in the CAD (computer aided design) program named CATIA. The new model's fingers contained a distal interphalangeal joint and a proximal interphalangeal joint. The addition of these joints allowed the prosthetic hand to not only function similarly to human fingers, but also to appear more realistic. In addition, instead of making each finger the same length, the new finger designs differ in length based on the average male finger dimensions.

In this study, we incorporated the fold in the palm to not only make the model more accurate anatomically, but to maximize its grasping power. Both the new palm and finger designs improved the prosthetic hand's ability to grasp.

Grasping Patterns

In order to study the success of the prosthetic hand's ability to maximize power and stability when grasping, the grasp patterns themselves had to be studied. There are a lot of studies regarding to the kinematics of grasp patterns conducted by different researchers [9-15]. The grasp patterns are divided into different categories. These categories include power, intermediate, precision, and thumb positioning. These grasp pattern categories are conducted with the thumb being in either an abducted or adducted position.

This study focused primarily on the power grasp, specifically targeting the cylindrical grasp. In power grasp patterns, the palm roll generates stability, which increases the overall strength of the grasp. By incorporating the palm joint and adding the joints to the finger, the prosthetic hand in this study produced a greater power when performing the cylindrical grasp.

Final Design

By utilizing CATIA, the existing design was modified and created. When modifying the prosthetic hand, various factors were considered.

These factors included the anatomical advantage of incorporating a palm roll, as well as the anatomical advantages when incorporating the distal interphalangeal joint and the proximal interphalangeal joint. In addition, the studies involved in the various grasp patterns showed how useful changes like the palm roll addition could be. Taking this information into account, the final model was created.

Future Work

To fully study the motion and functionality of the mechanism, there has to be a control system incorporated. The desired control system will include servo motors connected to an Arduino Uno. The servo motors will not only control the fingers but also actuate the palm roll. With the motors and control board incorporated, the prosthetic hand can be studied for functionality.

When the motion of the prosthetic hand has been determined to be functional by conducting studies involving joint analysis, as well as having the prosthetic hand be able to hold various cylindrical items, the mechanism will be ready for the final test. The final test will involve adding force plates to the palm roll area. The data gained from this test will show us the grasping strength the palm roll provides, allowing us to determine if the mechanism has maximized grasp strength.

Conclusion

In this study, an existing prosthetic hand model was modified to incorporate an extra degree of freedom in the palm. In addition, more realistic finger designs were developed. The reason for this was to contribute a more complete and accurate design than current prosthetic hands in the industry.

The final model did have some limitations. The 3D printing process was more time consuming than expected. There were times when more prosthetic hands needed to be printed due to pro-

totypes breaking. This required readjustment of the prosthetic hand model to be conducted in order to print out a more structurally stable model. However, once the future experiments are conducted and processed, the data gained from the study will allow a more functional and anatomically accurate prosthetic hand to be created, which will advance the field of human prostheses.

References

[1] Amputee Coalition. (2015). *Limb Loss Statistics*. Retrieved from http://www.amputee-coalition.org/limb-loss-resource-center/resources-by-topic/limb-loss-statistics/limb-loss-statistics/>.

[2] Butterfaß, J., Grebenstein, M., Liu, H., and Hirzinger, G., 2001. "Dlr-hand ii: Nextgeneration of a dextrous robot 7 Copyright c 2016 by ASME hand." in Robotics and Automation, 2001. Proceedings 2001 ICRA. IEEE International Conference on, Vol. 1, IEEE, pp. 109–114.

[3] Van Der Niet Otr, O., Reinders-Messelink, H. A., Bongers, R. M., Bouwsema, H., & VanDer Sluis, C. K. (2010). The i-LIMB hand and the DMC plus hand compared: a case report. Prosthetics and orthotics international, 34(2), 216-220.

[4] Tuffield, P., and Elias, H., 2003. "The shadow robotmimicshumanactions."IndustrialRobot: *An International Journal*, 30(1), pp. 56–60.

[5] Dally, C., Johnson, D., Canon, M., Ritter, S., and Mehta, K., 2015. "Characteristics of a 3d-printed prosthetic hand for use in developing countries." In Global HumanitarianTechnology Conference (GHTC), 2015 IEEE, IEEE, pp. 66–70.

[6] "Choosing Hand Tools." Choose Hand Safety. CPWR, 2014. Web. 29 June 2016. <http://www.choosehandsafety.org/choosing-hand-tools/hand-tool-size>.

[7] "What Is the Average Male Finger Length?" Reference. Reference An IAC Publishing Labs Company, 2016. Web. 29 June 2016. https://www.reference.com/science/average-male-finger-length-68c2a7189f4628c1.

[8] Van Mensvoort, Martijn. "How Long Is Your Pinky Finger... Really?" *www.modernhandreadingforum.com*. PhpBB, 14 Sept. 2010. Web. 25 June 2016. <http://www.modernhandreadingforum.com/t187-how-long-is-your-pinky-finger-really>

[9] Cutkosky, M. R., 1989. "On grasp choice, grasp models, and the design of hands for manufacturing tasks." Robotics and Automation, IEEE Transactions on, 5(3), pp. 269–279.

[10] Napier, J. R., 1956. "The prehensile movements of the human hand." *Bone & Joint Journal*, 38(4), pp. 902–913.

[11] Fukaya, N., Toyama, S., Asfour, T., and Dillmann, R., 2000. "Design of the tuat/karlsruhe humanoid hand." In Intelligent Robots and Systems, 2000. (IROS 2000). Proceedings. 2000 IEEE/RSJ International Conference on, Vol. 3, IEEE, pp. 1754–1759.

[12] McPhee, S. D., 1987. "Functional hand evaluations: a review." *American Journal of Occupational Therapy*, 41(3), pp. 158–163.

[13] Dai, W., Sun, Y., and Qian, X., 2013. "Functional analysis of grasping motion." In Intelligent Robots and Systems (IROS), 2013 IEEE/RSJ International Conference on, IEEE, pp. 3507–3513.

[14] Sandra, J., Donna, J., and Jenna, D., 2002. "Developmental and functional hand grasps." *Thorofare: Slack Incorporated*, pp. 57–68.

[15] Feix, T., Pawlik, R., Schmiedmayer, H.-B., Romero, J., and Kragic, D., 2009. "A comprehensive grasp taxonomy." In Robotics, Science and Systems: Workshop on Understanding the Human Hand for Advancing Robotic Manipulation, pp. 2–3.

Exploring Student Use of Campus Mental Health Services and the Impact on Student Academic and Social Outcomes

Shawna Fitz

McNair Scholar, Wichita State University

Eveline Kalomo, PhD

Assistant Professor of Social Work

Summary

Although research regarding college mental health services exists, little information regarding student use of campus mental health services and their influence on student outcomes is present. This review examined student utilization of campus mental health services and whether these services affect social and academic outcomes for students.

Research indicates that adolescents are entering post-secondary education at a higher rate than in previous years, with nearly two-thirds of U.S. high school students entering college immediately after high school (GlenMaye & Bolin, 2007; Oswalt, Lederer, & Schrader, 2015). With the increase of adolescents pursuing a college education, analyzing current university practices in regards to student mental health is paramount to effectively aiding college students in achieving their education and career goals. Addressing student mental health practices on college campuses begins with identifying the role of the university for the student. According to Young and Armstrong (2015), post-secondary institutions are communities that hold inalienable obligations to their students. In regards to student mental health, Young and Armstrong (2015) were clear in indicating the role of the institution: to recognize their responsibility to their students as members of their community and to invest in the design or "contextualization" of their institution's student mental health services. Winterrowd, Priniski, Achter, and Abhold (2016) have suggested that student mental health services on campus have a likely effect of improving student mental health.

Attempts to investigate just how schools can affect their students' mental health have yielded mixed results, which led Sara Oswalt (2015) to conclude that the paucity of research available on institutional characteristics and how they relate to student health is an area of concern. However, research into individual factors that affect student mental health has shown steady advancement. In consideration of a student's individual characteristics relating to mental health, terms such as mental health literacy, stigma, and help-seeking behaviors are areas of noted research. Mental health literacy refers to the "ability to accurately rec-

ognize specific disorders, knowledge about how to seek mental health information, attitudes that facilitate problem recognition, help-seeking, knowledge and beliefs about risk factors and causes for mental illness, self-help interventions, and available professional help" (Armstrong & Young, 2015, p. 2). Stigma is a term prevalent in mental health literacy. Mendoza, Masuda, and Swartout (2015) defined stigma as, "a multidimensional process of objectifying and dehumanizing a person known to have or appearing to have a mental disorder" (p. 209). Help-seeking behavior is often discussed in student mental health research. Daniel Eisenberg (2012) stated that help-seeking behavior targets a student's use or disuse of mental health services and the factors that affect it, such as attitudes, beliefs, and knowledge.

The attitudes of students, from a variety of demographics, towards the stigma of mental illness are a well-studied area of mental health (Mendoza et al., 2015). Additionally, use of mental health counseling services on campus increases self-efficacy for college students across multiple demographics (Mendoza et al., 2009). Two major barriers of helping students with mental health disabilities, besides lack of research or mixed results in studies, are the lack of legislative impact and funding for this type of health care (Armstrong & Young, 2015; Eisenberg et al., 2012; Kiuhara & Huefner, 2008). Wynaden et al. (2014) agreed and reminded researchers that addressing student mental illness not only requires the work of practitioners and faculty, but also requires an effort by policy makers. This could be accomplished through the relationship that post-secondary institutions and legislators have through the Americans with Disabilities Act (ADA), which had been implemented in 1990 in an effort to create opportunities for students with psychiatric disabilities to be academically successfully (Salzer, Wick & Rogers 2008).

For college students, the impact of mental illness not only affects personal goals, but academic and professional goals as well. It is with this knowledge that a growing belief that services supporting mental health in post-secondary institutions have

an obligation to provide access and opportunities for students to be academically successful. This includes evaluation and implementation of the best evidence-based practices on their campuses, educating teachers about student mental health issues, and writing legislation, protocols, and policies that support the importance of student mental health in post-secondary settings. Moreover, when discussing support available for students with disabilities, Susan Wilhelm (2003) noted the importance of accommodations for students suffering from mental health issues. Under the ADA a student may receive reasonable accommodations that are tailored to his or her functional needs, such as additional time on exams and alternate exam formats. It is important that psychological disorders, such as bipolar disorder, major depression, and anxiety disorders (including post-traumatic stress disorder and panic disorder) are protected under the act. Although accommodations are meant to help eliminate or reduce the impact of a student's impairment, there is little research to support the effectiveness of these accommodations.

Student mental health research is a growing field; however, the lack of research into its models, interventions, and studies has been cited as another barrier to advancing the field. Moreover, there is a general consensus that mental health concerns among post-secondary students are an increasingly serious issue. No clear remedy to this problem has presented itself. Research investigating student mental health is varied, and depending on one's focus (i.e. mental health literacy, help-seeking behavior, campus interventions, or legislation and funding), an investigation into this area can yield a wealth of information or present a notable dearth of empirically-derived data. Researchers continue to evaluate which personal, intrapersonal, or institutional factors have an effect on student mental health, as well as what avenues are available to policy-makers, institutions, clinicians, and stakeholders in advancing the field of mental health for students in post-secondary settings. Summarily, recommendations for advancing student mental health research are varied; how-

ever, legislation, financial aid and student mental health services on campus have been routinely cited as crucial intersections within student mental health research. Post-secondary institutions have a variety of roles: mental health service providers, financial aid/grant distributors, and higher learning environments. Above all, they play a pivotal role within student mental health and should continue to implement programs that support their students and their students' goals.

References

Armstrong, L. L., & Young, K. (2015). Mind the gap: Person-centered delivery of mental health information to post-secondary students. *Psychosocial Intervention/Intervencion Psicosocial. Aug2015, 24*(2), 83. doi:10.1016/j.psi.2015.05.002

Eisenberg, D., Hunt, J., & Speer, N. (2012). Help Seeking for Mental Health on College Campuses: Review of Evidence and Next Steps for Research and Practice. doi:712839

GlenMaye, L. F., & Bolin. (2007). Students With Psychiatric Disabilities: An Exploratory Study Of Program Practices. *Journal of social work education, 43*(1), 117.

Kiuhara, S. A., & Huefner, D. S. (2008). Students With Psychiatric Disabilities in Higher Education Settings: The Americans With Disabilities Act and Beyond. *Journal of Disability Policy Studies, 19*(2), 103-113. doi:10.1177/1044207308315277

Mendoza, H., Masuda, A., & Swartout, K. M. (2015). Mental health stigma and self-concealment as predictors of help-seeking attitudes among Latina/o college students in the United States. *International Journal for the Advancement of Counseling, 37*(3), 207-222.

Oswalt, S. B., Lederer, A. M., & Schrader, L. T. (2015). Institutional Characteristics and the Connection to College Student Health. *American Journal of Health Behavior (AM J HEALTH BEHAV), Jul/Aug2015*. doi:http://dx.doi.org.proxy.wichita.edu/10.5993/AJHB.39.4.4

Salzer, M. S., Wick, L. C., & Rogers, J. A. (2008). Familiarity with and use of accommodations and supports among postsecondary students with mental illnesses. *Psychiatric Services, 59*(4), 370-375.

Wilhelm, S. (2003). Accommodating mental disabilities in higher education: A practical guide to ADA requirements. *JL & Educ., 32*, 217.

Winterrowd, E., Priniski, S. J., Achter, J., & Abhold, J. J. (2016). Correlates of Satisfaction, Intrapersonal Learning, and Academic Outcomes at Counseling Centers in a University System. *College Student Journal, 50*(2), 288-301.

Wynaden, D., McAllister, M., Tohotoa, J., Omari, O. A., Heslop, K., Duggan, R., ... Byrne, L. (2014). The Silence of Mental Health Issues Within University Environments: A Quantitative Study. *Archives of Psychiatric Nursing (ARCH PSYCHIATR NURS), Oct 2014*. doi:http://dx.doi.org.proxy.wichita.edu/10.1016/j.apnu.2014.08.003

Resilient Grandparents: An Exploration of the Expanding Role of Grandparent as Caregiver

Vera Gantt

McNair Scholar, Wichita State University

Eveline Kalomo, PhD

Assistant Professor of Social Work

Summary

Grandparent caregiving is not a new phenomenon, as kinship caring has traditionally been a part of family life. According to the U.S. Census Bureau, in 1970 2.2 million children under 18 lived in grandparent-headed households. In 1997, approximately 4 million children lived with their grandparents (Park, 2005). Since the late '90s, the fastest growing type of grandparent-headed household is one in which a child's biological parent is not present (Park, 2005).

The reasons for care provision are a reflection of some of the challenging social conditions that exist in our society. Grandparents become responsible for their grandchildren for primarily the following reasons: parental substance abuse, incarceration of parents, death due to HIV/AIDS of biological parents, and divorce of parents. In addition, mental health illnesses of the parents, abuse by parents, neglect, and abandonment of children all contribute to the inability of some biological parents to raise their children (Carlini-Marlatt, 2005).

Existing research has primarily focused on the health and well-being of grandparents. Studies have found grandparents who are primary caregivers reported more health-related concerns and issues than grandparents who do not have custody of their grandchildren. Bachman and Lansdale (2005) found grandmothers who raise grandchildren reported increased rates of physical health problems. A study conducted by Ross and Aday (2006) found 92% were experiencing clinically significant levels of stress, and Del Bene (2010) discovered 86% of grandparents who raise grandchildren felt depressed, 61% reported increased smoking, and 36% complained of heightened medical illnesses.

Increasingly, grandparents are being called on to raise their grandchildren when parents are unable or unwilling to fulfill their parenting role. Caregiving grandparents often find themselves in an economic bind. Financially, most are at a stage in life where they are looking to retire and reduce family spending, but raising a school-aged child dramatically alters their plans. Research has shown financial worries are a major issue for most grandparents raising their grandchildren. Park (2005) found that three-fifths of single grandmothers in skipped generation families reported annual incomes of $20,000 or less, and over a quarter reported annual incomes of $10,000 or less. Moreover, in 1996, Aid to Families with Dependent Children

(AFDC) was replaced by Temporary Assistance for Needy Families (TANF), which caused great concern about the possible detrimental effects TANF could have on households that were headed by grandparents (Park, 2005). Grandparents who receive TANF are required to adhere to the same policies as other recipients; they are required to participate in the work force no later than 24 months after receiving benefits and face the same time constraints on how long they can receive assistance over a lifetime, which is five years (Park, 2005). This poses a huge dilemma for grandparents who assume responsibility of their grandchildren as they are less competitive in terms of participating in the workforce, and they may also be facing declining health and chronic illness. The participants in a study conducted by Williamson, Softas-Nall, and Miller (2003) reported general unhappiness, anxiety, and stress over financial woes, along with reported annual incomes of $12,000 to $75,000.

This paper explored the vital role grandparents play in their grandchildren's lives. This group of individuals is a unique group that has made exceptional contributions to children whose parents are unable to raise them. It is important for those who provide social services to these families to be cognizant and empathetic to the challenges they face. With the high rates of poverty faced by single grandmothers, policymakers need to reconsider economic policies and develop a deeper and more precise understanding of the emotional side of re-parenting that currently places grandparents at a disadvantage. Finally, there needs to be much consideration for grandparents in the workforce as they need family-friendly policies and programs made available to them. Economic hardship affects their ability to care properly for their family as well as maintain their well-being.

Given the number of economic and caregiving challenges facing low-income custodial grandmothers, further examination of their coping techniques and health behaviors may be an important area for future research (Bachman and Landsdale, 2005). In addition, exemptions from work requirements are imperative as grandmothers may benefit more from increased healthcare access and respite childcare assistance to aid in reducing their caregiving burdens.

References

Bachman, H. J., & Lansdale, L. C. (2005). Custodial grandmothers' physical, mental, and economic well-being: comparisons of primary caregivers from low-income neighborhoods. *Family Relations*, *54*(4), 475-487.

Carlini-Marlatt, B. (2005). Grandparents in Custodial Care of their Grandchildren: A Literature Review. Prepared for Mentor UK. Retrieved on February 15, 2016 from www.mentorfoundation.org/.../UK_Grandparents_Lit_Review.pdf

Del Bene, S. B. (2010). African American grandmother raising grandchildren: a phenomenological perspective of marginalized women. *Journal of Gerontology Nursing 36*(8) 32-40.

Park, H. O. (2005). Grandmothers raising grandchildren: family well-being and economic assistance. *Focus*, *24*(1), 19-27.

Ross, M. E. T., & Aday, L. A. (2006). Stress and coping in African American grandparents who are raising their grandchildren. *Journal of Family Issues*, *27*(7), 912-932.

Williamson, J., Softas-Nall, B., & Miller, J. (2003). Grandmothers raising grandchildren: an exploration of their experiences and emotions. *The Family Journal: Counseling and Therapy For Couples and Families*, *11*(1), 23-32.

Investigating Guiding Attributes in Visual Search for Medication Vials

Logan M. Gisick
McNair Scholar, Wichita State University

Evan M. Palmer, PhD
Associate Professor of Psychology

Summary

Medical professionals select from a vast array of medication vials to dispense the correct medication to a patient. The vials are often small and highly similar, potentially increasing the chance for a medical professional to commit an error.

The most recent study on the scope of medical errors used a program called the Global Trigger Tool, which guides reviewers through medical records and flags specific evidence of adverse effects. Using this tool, researchers collected data from hospitals worldwide between 2008 and 2011 and concluded that the current rate for premature death due to medical errors has skyrocketed, from the 98,000 per year that the "To Err is Human" report established in 1999 (ISMP Medication Safety Alert, Vol. 7) to more than 400,000 individuals (James, 2013).

In addition to the loss of human life, there are serious financial losses associated with medical errors. Preventable hospital care associated with adverse effects, for Medicare alone, amounted to an estimated $4.8 billion in 2008 (Levinson & General, 2010). The estimate included extended hospital stays, unnecessary treatment or surgery to correct a problem as a result of an adverse event, and medical professional liability costs. Studies have shown that 33% of medical errors are due to packaging and/or labeling confusion (Berman, 2004, p. 16).

Vision researchers Wolfe & Horrowitz (2004) assembled a comprehensive list of features that are believed to "pop-out" in the visual field. These features have been known as Basic Features, Learning Features, Primitive Features, and Preattentive Features; however, in this paper they were referred to as Guiding Attributes, as identified by Wolfe & Horrowitz. Stimuli containing one or more of these features are often located with higher accuracy and decreased Response Time (RT).

Wolfe and Horowitz's research found that no single diagnostic assures the presence of a Guiding Attribute. This is why our study examined the effect of not only the independent variables of color density, text orientation, and text size, but also observed the interaction that occurs when these elements are combined, thus, determining which variable or grouping of variables guide attention.

In a series of three experiments conducted by Gisick and Palmer (2014), a visual search paradigm programmed in MATLAB was used to study the visual characteristics of medication vial labels to identify properties leading to the fastest and most accurate search.

In the first experiment, significant main effects were found for Text Orientation, $F(1,29) = .18.52$, $p < .001$, $\eta_p^2 = .390$ and for Color Density, $F(2,28) = 12.77$, $p < .001$, $\eta_p^2 = .477$. The data indicated that the medication vials with vertical orientation and/or high color density were more quickly recognized.

When analyzing the data for accuracy, significant main effects were found for Text Orientation, $F(1,29) = 10.04$, $p < .005$, $\eta_p^2 = .257$ and Color Density, $F(2,28) = 17.99$, $p < .001$, $\eta_p^2 = .562$, indicating that medication vials with vertical orientation and/or high color density were more accurately recognized.

Experiment two focused on the label of the medication vial in order to make sure we were observing only the effect of the label, without interference from the cap or the rest of the vial. A similar experiment that excluded all parts of the vial except for the label was conducted.

Participants' RT indicated significant main effects for Text Orientation, $F(1,30) = 22.768$, $p < .001$, $\eta_p^2 = .431$, Text Size, $F(1,30) = 4.238$, $p < .05$, $\eta_p^2 = .124$, and Color Density, $F(2,29) = 297.006$, $p < .001$, $\eta_p^2 = .908$. The Text Orientation, Text Size, and Color Density main effects indicated that medication vials with vertical orientation, and/or large text, and/or high color density were more quickly recognized. There was also a Text Size x Text Orientation interaction showing that horizontal text was located significantly faster when text was large.

Analysis of accuracy data showed a main effect for Color Density, $F(2,29) = 47.356$, $p < .001$, $\eta_p^2 = .612$. The analyses also indicated significant interactions for Text Size and Orientation, $F(1,30) = 29.895$, $p < .001$, $\eta_p^2 = .499$. The Color Density main effect indicated that medication vials with high color density were more accurately recognized, and the interaction showed that vials with small text size were located significantly more accurately when the text orientation was vertical and slower when the text orientation was horizontal.

After discovering significant main effects for text orientation in both Experiments 1 and 2, a decision was made to look even closer at the relationship between the text orientation of a medication vial and the efficiency with which it is searched for among an array of distractors. In order to do this, search efficiency needed to be examined when the only difference between the two compared vials is the orientation of the label. This led to designing and conducting Experiment three, which used two different set sizes (six and twelve) in order to compare the search efficiency in the form of slopes.

Participants' RT results indicated a significant main effect for Set Size, $F(1,8) = 35.438$, $p = .001$, $\eta_p^2 = .835$, and so did their results for accuracy, $F(1,8) = 6.795$, $p < .05$, $\eta_p^2 = .493$. This was to be expected, and there were no significant differences in search efficiency between horizontal and vertical medication vial labels.

The purpose was to examine whether or not the significance of guiding attributes that have been discovered in basic visual research could be applied to the real world in a visual search for medication vials.

Experiments one and two revealed that vials with high color density were located more quickly and accurately across all conditions. Significant interactions between text size and text orientation were also found: when the text orientation is vertical, small text is located significantly faster, but when the text orientation is horizontal, large text is located significantly faster. Experiment three yielded no significant differences between horizontal and vertical orientation of labels, but showed the predicted increase of RT with set size. This research suggests that increasing the color density of medication vial labels will allow for quicker and more accurate search and may lessen the probability of experiencing a medical error.

References

Berman, A. (2004). Reducing medication errors through naming, labeling, and packaging. *Journal of medical systems*, *28*(1), 9-29.

Gisick, L. M. & Palmer, E. M. (2014). Investigating guiding attributes in visual search for medication vials. *McNair Scholars Program Journal of Research Reports, 19,* 27-37.

ISMP Medication Safety Alert, Vol. 7, No. 7, April 3, 2002.

James K. L., Barlow D., McArtney R., Hiom S, Roberts D, Whittlesea C. (2009). Incidence, type and causes of dispensing errors: a review of the literature. *International.* Journal of *Pharmaceutical Practice. 17,* 7–8.

Levinson, D. R., & General, I. (2010). Adverse events in hospitals: national incidence among Medicare beneficiaries. Department of Health & Human Services.

Wolfe, J. M., & Horowitz, T. S. (2004). What attributes guide the deployment of visual attention and how do they do it? *Nature Reviews Neuroscience, 5*(6), 495-501.

Thermal Spray Coatings
on Magnesium

Jesus G. Gonzalez Flores
McNair Scholar, Wichita State University

Anil Mahapatro, PhD
Assistant Professor, Department of Biomedical Engineering

Summary

Due to their combination of excellent mechanical properties and toughness (Hanawa, 2005), metals have been greatly accepted for use in medical applications. Metals have the longest history of use among the various biomaterials (Niinomi, 2002). Although metals have great properties as implantable materials, they also have various limitations. Corrosion and mechanical wear are usually the most common problems with current metal implantables. Due to metal corrosion, the efficacy in performance of the implantable is diminished by creating wear particles that may also cause infection. Magnesium (Mg) is a metal that is being considered as a potential biodegradable metal; however, it rapidly reacts with physiological solutions and produces hydrogen gas in non-toxic concentrations. Magnesium and its alloys have gained footing as an alternative biocompatible material (Witte et al., 2005; Weizbauer, 2013).

As a fixation device, Mg lines up very well due to its similarities to bone in elastic modulus. In addition, as a main degradation product, Mg is an essential trace element for human enzymes. The amount of Mg the implant discharges once it begins to corrode and how well it sustains its mechanical structure were some of the limitations observed in this study. The byproducts of Mg degradation have been shown to improve osteoconductivity (Puleo & Huh, 1995), but the hydrogen gas produced presents a problem when the material is being employed for orthopedic applications because it creates a subcutaneous cavity. With the advanced capabilities in alloy composition available today, the properties of Mg have improved considerably; however, no current alloy exists to satisfactorily perform in biomedical applications. Porous metallic coatings of zinc on a Mg substrate could serve as a potential route to slow the degradation of Mg while providing other benefits.

There is a gap in the study of coating Mg with zinc on thermal spray applications, specifically for biomedical applications. However, there is literature on electroplating, dating back to 1957 (De Long Herbert, 1957). Our study hoped to improve the view of zinc as a coating strategy for magnesium and its alloys, thus, contributing to the development of fracture fixation devices that do not require a secondary surgery to remove.

The coating application was carried out manually using a TAFA 8830 arc spray system. The coating applied was from a zinc wire of 99.9% purity with less than .004% copper. The wire was TAFA 02Z of 1.5875 mm thickness. The experiment was conducted using changes in distance, while the amperage and air flow were kept to the recommended settings. Roughness (Ra) is a measurement of the surface topography of

any sample; the Ra measurement was calculated by an algorithm that measures the average length between the peaks and valleys and the deviation from the mean line on the entire surface within the sampling length. Ra averages all peaks and valleys of the roughness profile and then neutralizes the few outlying points so that the extreme points have no significant impact on the final results. The measurements for this experiment on the arc spray zinc coating displayed that the more distance the spray system and substrate had, the greater the Ra measurement.

In our data the distance the gun was from the substrate had a large impact on deposit efficiency. The resulting coating thickness of each sample steadily dropped as separation grew between the sample and the molten spray particles. Due to the nature of the spray system, where the material fans out from the origin, this was an appropriate result. The measurements of thickness from calipers corroborated the results. Although the changes were not as drastic as expected, they still showed a steady decline the greater the distance between the spray system and the substrate. The measurement with the micrometer encompassed a larger surface area of the coating, making for an average of area rather than a single point in the image measurements.

The hardness of the material was seen to decrease as more distance was put between sample and gun system. This could be because as distance increases so does the travel time of the molten particles. Usually in these conditions, a larger distance from substrate to spray system increases hardness due to oxide formation, especially because the material cools quickly as it travels (Krupinska et al., 2010). Another possible reason for this decrease, in comparison to other experimental results, could be due to the use of air cooling jets to maintain the substrate from overheating. This was an original precaution to prevent the substrate from oxidizing but could have inadvertently produced other complications, such as problems with coating application and coating properties. The use of magnesium as a substrate could be the reason for this change as well.

To have a better understanding of this coating strategy, more work is necessary. Studying the degradation behavior is the next step for this research. Once the data from the degradation behavior of arc sprayed zinc coatings is collected, comparisons with the currently employed coatings that slow down degradation on Mg for biomedical purposes can be done. Other studies have characterized zinc coatings using other forms of thermal spray systems, like Flame Spraying or HVOF. The study with HVOF had Mg as a substrate, but the coating was stainless steel (García-Rodríguez, López, Torres, & Rams, 2016). Our study differs from both because Kobayashi, Maruyama, and Kano (2003) employed different substrates that did not include Mg, and the other employed a different metal coating (García-Rodríguez et al., 2016).

Our study had the goal to improve the view of zinc as a coating strategy for Mg and its alloys, thus, contributing to the development of fracture fixation devices that do not require a secondary surgery to remove. When applying the arc sprayed zinc coating, the variable that was changed was the distance from substrate to gun, while the surface roughness, microhardness, and microstructure were observed for changes. Microhardness dropped as distance grew further between the substrate and spray system; the thickness of the sample was clearly reduced as well. Another thing that decreased as distance was increased was the surface roughness of the coating. With the decrease in hardness one can assume more porosity is the cause, but it can also be the change in temperature and slight heat treat effect that those at a close distance might experience. In the future, the corrosion behavior of the applied coatings and the effect of the substrate and distance can be assessed. Similarly, a study and quantification of the porosity of the coatings should be done.

References

De Long Herbert, K. (1957). *U.S. Patent No. 2,811,484*. Washington, DC: U.S. Patent and Trademark Office.

García-Rodríguez, S., López, A. J., Torres, B., & Rams, J. (2016). 316L stainless steel coatings on ZE41 magnesium alloy using HVOF thermal spray for corrosion protection. *Surface and Coatings Technology, 287*, 9-19. doi: 10.1016/j.surfcoat.2015.12.075

Hanawa, T. (2005). Roles of metals on regenerative medicine. *Journal of Hard Tissue Biology, 14*(2), 140-142. http://doi.org/10.2485/jhtb.14.140

Kobayashi, T., Maruyama, T., & Kano, M. (2003). Characterization of pure aluminum and zinc sprayed coatings produced by flame spraying. *Materials Transactions, 44*(12), 2711-2717. http://doi.org/10.2320/matertrans.44.2711

Krupinska, B., Dobrzanski, L., Rdzawski, Z., & Labisz, K. (2010). Cooling rate influence on microstructure of the Zn-Al cast alloy. *Archives of Materials Science and Engineering, 43*(1), 13-20.

Niinomi, M. (2002). Recent metallic materials for biomedical applications. *Metallurgical and materials transactions A, 33*(3), 477-486. doi: 10.1007/s11661-002-0109-2

Puleo, D. A., & Huh, W. W. (1995). Acute toxicity of metal ions in cultures of osteogenic cells derived from bone marrow stromal cells. *Journal of Applied Biomaterials, 6*(2), 109-116. doi: 10.1002/jab.770060205

Witte, F., Kaese, V., Haferkamp, H., Switzer, E., Meyer-Lindenberg, A., Wirth, C. J., & Windhagen, H. (2005). In vivo corrosion of four magnesium alloys and the associated bone response. *Biomaterials, 26*(17), 3557-3563. doi: 10.1016/j.biomaterials.2004.09.049

Weizbauer, A., Modrejewski, C., Behrens, S., Klein, H., Helmecke, P., Seitz, J. M., ... & Waizy, H. (2013). Comparative in vitro study and biomechanical testing of two different magnesium alloys. *Journal of Biomaterials Applications, 28*(8), 1264-1273. doi: 10.1177/0885328213506758

Cell Material Interactions of Laser Modified Orthopedic Implants

Martina Salerno

McNair Scholar, Wichita State University

Anil Mahapatro, PhD

Assistant Professor, Department of Biomedical Engineering

Summary

Postoperative infection of implantable orthopedic devices frequently occurs as a complication of orthopedic surgery. These infections often compromise medical device function. Minimizing infection would improve the integration of orthopedic implants, such as plates or screws, with bone tissue and lead to the enhanced stability of implants, which is important for proper function and patient safety. Biomaterials used for orthopedic implants are modified in order to improve biocompatibility and minimize orthopedic implant rejections. Modifications of biomaterials usually occur at the surface or interface, where the material will meet the host environment. Patterning and topographical surface modifications are used as a biomimetic technique to enhance cell adhesion to a biomaterial. This type of modification improves biocompatibility via mechanical interlocking of the implant with the host bone [1, 2]. In order to combat infection, biomaterials and functional coatings used for medical implants are evaluated either for their ability to resist infection (resist bacterial adhesion and biofilm formation) or for their ability to integrate tissue (to support tissue cell adhesion and proliferation). No viable clinical technology currently exists to address both these issues simultaneously. Our hypothesis was that laser micro-nano machining can create surface topographies on orthopedic implant surfaces that could provide a platform for simultaneous tissue integration and therapeutic delivery for biofilm prevention.

Many institutions have concluded a positive relationship between cell growth and attachment with increased surface roughness. Roughness created by surface modification has been successful at the micro and nanoscales, while the nanoscale has been identified as an optimal surface roughness range [2, 3]. Additional surface area created by a rough interface, as well as the ability for mechanical interlocking, allows for promotion of tissue integration and, therefore, a decrease in postoperative infection [2].

Although alternate types of patterning could be used in order to provide these beneficial results, laser surface treatment was used to create micro-nanoscale three dimensional structures on the surface of stainless samples. Laser surface modification was used as a patterning method because of its versatile control of size, depth, and spacing; its non-contact process; and ability to maintain chemical make-up of samples [1,2, 4-6]. Laser patterning of samples emulating orthopedic implants has previously been constructed with different parameters, materials, and different topographical structure construction [1, 4].

In the present study, the biometal 316L stainless steel was patterned using laser surface treatment at

the micro-nano scale. The patterned samples were characterized visually and then evaluated for cell material interaction using a cytotoxic elution process. The purpose of carrying out a cytotoxicity evaluation is to determine potential cytotoxicity of a material being studied [7]. Cytotoxicity is the measure of toxicity a component or material has regarding cell life. All materials interacting with the human body, such as orthopedic implants, must be evaluated for toxicity in order to maintain patient safety. For this study we evaluated the cytotoxicity of micro-nano textured samples on a fibroblast cell line called L929 from mice. The evaluation compared a set of 316L stainless steel (medical grade stainless steel) samples for their cytotoxicity. Two samples of un-patterned SS were used and two laser patterned SS samples were used. Both sample sets were compared to control wells which are known to induce positive cell growth. The main goal of the study was to verify that the laser patterned SS samples would interact with cells in the same way that un-patterned SS samples would, and that both SS samples would interact in such a way to demonstrate biocompatibility.

316L stainless steel is a medical grade bio-metal used for orthopedic devices; samples 316L stainless steel were used to emulate orthopedic implants. 316L stainless steel has iron, chromium and nickel components and is low in carbon content which contributes to its enhanced corrosion resistance [8]. SS samples were cut into uniform squares and cleaned before undergoing laser modification. Samples to remain un-patterned were set aside while other samples were patterned using a Coherent™ Avia 355X nanosecond pulsed laser. Laser surface texturing was carried out in an inert gas chamber to prevent unwanted exposure and contamination of surfaces. Uniform parameters were used to pattern each sample, and characterization of the samples was carried out through optical microscopy and scanning electron microscopy. Through imaging at multiple resolutions, a grating raster pattern was visualized on each sample with a pattern width of about 100 μm, which verifies a radically different surface morphology

for laser patterned samples when compared to un-patterned samples.

The cytotoxicity evaluation was completed in correlation with the ISO 10993-5, 2009 (Tests for *in vitro* cytotoxicity) guidelines using the elution test, which uses liquid extracts of materials; the test was carried out to compare control wells (with no material), un-patterned 316L stainless steel (SS), and laser surface textured 316L SS samples [9]. Elution tests are a widely used cytotoxicity evaluation for *in vitro* environment and evaluate components and how they affect cell viability. The process involves incubating materials with medium used to grow cells, then incubating cells with that medium to evaluate how the materials indirectly affect cells [10]. Cell viability was quantified by counting cells and can be seen by images taken before and after the experiment was done. Two samples of each material were used. Each material was exposed to complete media for 24 hours and then media was used to supplement cells for an incubation period of 24 hours. Each plate was seeded so that all samples and the control well had the same number of cells before incubation. The effect of materials on cells was able to be evaluated by comparing viable cell counts after incubation of each sample to the control; three aliquots were taken from each sample well and averaged to limit inaccuracy of counting. Using cell counts obtained with the hemacytometer counting method, cell viability percentages were calculated.

Quantitative evaluation of the 24-hour cytotoxicity study revealed that, compared to the control well, both the un-patterned and laser patterned samples behaved essentially the same way at above 85% of control growth. Since reduction of cell viability over 30% is considered to be a cytotoxic effect by the material being tested, neither the SS sample nor the patterned SS sample are considered cytotoxic and are, therefore, considered biocompatible [9, 10]. When normalizing cell viability to the un-patterned SS sample, the patterned stainless steel induced positive cell growth. Results revealed a small increase in the number of cells present for the patterned sample than the un-patterned sam-

ple; However, this data could vary as more trials are completed.

Imaging and visual characterization through optical microscopy and scanning electron microscopy verified that laser surface modification is a successful bio-metal patterning method, but parameters can be further tuned to achieve a more defined three-dimensional structure. The results obtained from the 24-hour fibroblast elution study verify the ability of laser textured 316L stainless steel as a biocompatible construct that could potentially be used for orthopedic implants. Our hypothesis that laser machining can create surface topographies on orthopedic implant surfaces that could provide a platform for simultaneous tissue integration and therapeutic delivery for biofilm prevention can be supported by further evaluations. Further research in this area can be conducted using the same set of SS samples, but evaluating cell viability over various incubation durations, including a three-day and seven-day study. Cytotoxicity research regarding other patterned biometals such as titanium and cobalt chromium alloys can also be completed.

References

[1] Palmquist, A., et al., "Acute Inflammatory Response to Laser-Induced Micro- and Nano-Sized Titanium Surface Features," *Clinical Implant Dentistry and Related Research*, no. 1, pp. 96. 2013.

[2] Oshida, Y., et al., "Dental Implant Systems," *International Journal of Molecular Sciences*, vol. 11, no. 4, pp. 1580-1678, 2010.

[3] Vandrovcová, M. and L. Bačáková, "Adhesion, Growth and Differentiation of Osteoblasts on Surface-Modified Materials Developed for Bone Implants," *Physiological Research,* vol. 60 no. 3, pp. 403-417, 2011.

[4] Qin, L., et al., *Response of MC3T3-E1* "Osteoblast cells to the microenvironment produced on Co-Cr-Mo alloy using laser surface texturing." *Journal of Materials Science*, vol. 49 no. 6, pp. 2662-2671, 2014.

[5] Hallgren, C., et al., "An in vivo study of bone response to implants topographically modified by laser micromachining." *Biomaterials*, no. 24, pp. 701-710, 2003.

[6] Vora, H.D. and N.B. Dahotre, "Laser surface heat treatment and modification: laser surface modification techniques provide a new path to enhance a material's resistance to the detrimental effects of corrosion, abrasion, and wear," *Advanced Materials & Processes*, no. 11, pp. 45, 2013.

[7] Freshney, R.I., *Culture of Animal Cells : A Manual of Basic Technique and Specialized Applications*. 7th Ed. Hoboken, N.J., USA: Wiley-Blackwell, 2016.

[8] Ratner, B.D., *Biomaterials science [electronic resource]: an introduction to materials in medicine,* 3rd ed. B. D. Ratner, Hoffman, A, F. J. Schoen, and J. E. Lemons, Eds. Amsterdam; Boston: Elsevier/Academic Press, 2013.

[9] *ISO 10993-5 Biological evaluation of medical devices-Part 5: Tests for in vitro cytotoxicity*, Copyright International Organization for Standardization, 2009.

[10] Xian, W., *A laboratory course in biomaterials.* SciTech book news, 2009.

Testing of the Hill-Type Muscle Mechanics Model while Pedaling in Relation to Muscle Fiber Strain Using Ultrasonography

M. Gabriela Valverde
McNair Scholar, Wichita State University

Nils Hakansson, PhD
Assistant Professor of Biomedical Engineering

Summary

The study of biomechanics is dedicated to the understanding of structure and function of biological systems. When considering human skeletal muscles, early researchers knew almost nothing about the internal composition of these structures, but they attempted to plot their corresponding input-output characteristics in an effort to derive a mathematical model to illustrate its overall functionality. Early efforts and applied mechanical laws led to a better understanding of muscle performance through computer simulation technologies and a mathematical model called the Hill-Type Muscle Model. Physiologically relevant models of muscle force generation are essential for creating realistic large-scale simulations to examine the role of muscle properties in controlling movement and posture [1].

Today, muscle models produce rational outputs that comparatively illustrate behavioral representations of real muscle activity, but because muscle functions are challenging and limiting to assess *in vivo*, the accuracy of the Hill-Type Muscle Model needs to be tested. Biomechanical models do not have to produce exact behavior, but the behavior should be within some well-defined range of error [2]. The imitation of real muscle performance through the Hill-Type Muscle Model form most well-utilized, non-invasive, method used for assessing the functions of muscles across the spectrum of skeletal muscle movements. Because of its adequate complexity and representation, the Hill-Type Muscle Model is the predominant theoretical model used in biomechanical simulations of multi-joint systems.

This Hill-type Muscle Model is made-up of three elements that represent the muscle's mechanical response. Its composition depends on a contractile element (CE), consisting of a mechanical energy source and two-linear spring elements; one serial element (SE); and one parallel element (PE). The CE represents the active fiber bundles in the muscle; its force largely depends on current length of the muscle fibers. Essentially, the active force is derived from the force created by myosin and actin cross-bridges at the sarcomere level, which is fully extensible in inactivation but capable of shortening when active [3].

Biomechanical simulations and clinical applications depend on the Hill-Type Muscle Model for studies relevant to understanding muscle movement and human health. The goal of this study was to evaluate the accuracy of the Hill-Type Muscle Model by focusing on the CE and assessing muscle fiber length change while pedaling. The muscle fiber length and pennation angles of the right gastrocnemius lateralis were recorded using ultrasonography and will be measured directly in a later study. This output effort will contribute to the understanding of evolutionary and comparative significance in muscle design and musculoskeletal makeup. By evaluating and comparing fiber muscle fascicle strain from direct versus model measures, the CE of the Hill-Type Muscle Model will be effectively validated.

Before testing the Hill-Type Muscle Model, the motion capture of three participants was recorded to illustrate and trace pedaling displacement by using an eight-camera Optitrack motion capture system. The purpose of using a motion/performance capture system was to locate and record the change in position of the right gastrocnemius lateralis while pedaling. By using CORTEX motion capture software and a series of reflective markers on the right leg, following the Helen Hayes marker placement, raw data of static state, dynamic state, and pedaling forces was gathered to further convert each participant's pedaling movement into a computerized virtual simulation. The next step will essentially take place using MatLab multiphysics. By using Matlab coding and programming, the necessary coordinate system and unit conversions for the analog data will be transformed into the correct OpenSim software format. OpenSim will assimilate these files to replicate the recorded pedaling motion using a lower limb musculoskeletal model and its integrated Hill-Type Muscle Model representations. Once the model is completed through OpenSim, with all of the paired processed motion data, the musculoskeletal model will be capable of estimating and disclosing changes in fiber length and pennation angles originating from the Hill-Type Muscle Model.

The muscle fiber strain output and force using OpenSim will then be compared to the direct measurements from collected ultrasonography video images. The ultrasound video images for each subject were captured simultaneously with the motion capture system. These were retrieved as audio video interleaved (AVI) files and will be converted to recognizable uncompressed formats to measure muscle fascicles using Image J, a public domain used for image processing and analysis. Once the clearly displayed muscle fascicles are individually measured to determine change in length and pennation angle of the gastrocnemius lateralis, the validation of the Hill-Type Muscle Model will take place to establish accuracy.

This study represents one of the few attempts to validate the Hill-Type Muscle Model alongside directly measured *in vivo* muscle fibers using ultrasonography. Previous studies have considered motor movements such as walking and jumping; this is possibly the first study using pedaling to test the accuracy of the Hill-Type Muscle Model. Due to time constraints and technical difficulties, three out of the seven projected participants underwent preparation and data collection. A larger sample size will be crucial to authenticate data analysis and to accurately perform a comparison against the Hill-Type Muscle Model. The experimental data collected in this study using CORTEX and ultrasonography will contribute to the rest of the anticipated experimental data collection. All of the raw data will be post-processed for the optimization of the contractile element, an essential piece in determining the validity of the Hill-Type Muscle Model.

The objective of this study was to validate a portion of the Hill-Type Muscle Model by using segmental kinematics and ultrasonography advantages. This model represents in large part the study of human locomotion. Because muscle functions are challenging and limiting to assess *in vivo*, the accuracy of the Hill-Type Muscle Model is largely unknown and needs to be tested. With this study, the model will continue to improve so that more robust comparisons between direct and simulated

data can be made. Almost all muscle simulations follow tailored computerized mathematical models in conjunction with simulated data for published experimental studies. The accuracy portion of this model is important for the overall optimization of biomechanics simulations.

References

[1] E. J. Perreault, C. J. Heckman, & T. G. Sandercock, "Hill muscle model errors during movement are greatest within the physiologically relevant range of motor unit firing rates," *J. Biomechanics,* vol. *36,* no. *2,* pp. *211-218.* Feb. 2003.

[2] Y. C. Fung, *Biomechanics: Mechanical properties of living tissues.* New York: Springer-Verlag, 1993, pp.568.

[3] Martins, J., Pires, E., Salvado, R., & Dinis, P, "A numerical model of passive and active behavior of skeletal muscles," *Computer Methods in Applied Mechanics and Engineering,* vol. *151* no. 3-4, pp. 419-433. Jan. 1998.

Fracture Patterns of South-Central Kansas and Relations to Contractional Structures of the Midcontinent Region

Alvine Wetiba

McNair Scholar, Wichita State University

Keith Gray

Assistant Professor of Geology

Summary

Characterization of microscopic and macroscopic scales of geological features offer a direct insight into strain levels sustained by sedimentary rocks. The ultimate goal of this study was to investigate an inventory of fracture types, orientations, and locations across south-central Kansas. The field data related regional-scale fracture to an orogenesis, which is a mountain building event such as the Laramide deformation in the rocky mountain region area. Consequently, this research is important because the findings benefit researchers' understanding of the movement and migration history of important subsurface resources, including groundwater and hydrocarbons.

During folding, we investigated the relationship between fold development and its distribution in the sedimentary strata by looking at the fractures, micro-faults, and kinematic relationships. Kinematic relationships and fractures are present in few outcrops in south-central Kansas. The subject matter was first observed in 1968 when John Ward published fault maps for Butler and Cowley Counties. Melton (1929) illustrated how similar the correlation is between these faults and the northwest-striking joint set that he described in his article. Melton discussed how these faults and joints of Oklahoma are believed to have been formed by initial compressive stresses of the Ouachita orogeny. In his article, he described how the joint system in his report is related to the one Foley described. Foley's work, based on the origins of faults in Oklahoma, stated that the joints in south-central Kansas may have originated in the faults of Oklahoma. This study acknowledged the findings of Melton, but disagreed that the joints' origins were solely in Oklahoma. Although Ward's pioneering work was exceptional and extended the scope, content, and coverage of Butler, Cowley, Greenwood, Elk, Barber, and Kiowa counties, more recent studies from Berendsen and Blair (1986) have had implications for ancient tectonic processes and applications to hydrocarbon exploration. In addition, analyses of fracturing in the Ouachita Mountains (Melton, 1929) offered interesting academic conclusions that relate to one of the theoretical implications of our study.

Method

Traditional field methods were utilized to conduct geological research for surface bedrock mapping and the measuring of fracture orientations. These methods included using a brunton compass to measure the strike and dip, stereo nets, a Jacob staff to measure unit thickness, and a GPS to confirm accurate locations. The field data was constructed on a 1:24,000-scale topographic base map and then plotted on stereographic projection diagrams. A rose diagram illustrated major orientations that were helpful to prove one of the hypotheses. Furthermore, published geologic maps available from the Kansas Geological Survey helped place local bedrock compositions and fracture orientation data into a regional context. Geological data was superimposed on existing geology data of a preexisting map to produce a final map. Once this was done, geological interpretations were made. In order to collect data, a presented outcrop was thoroughly observed for all geological data, such as rock descriptions, formations, and relative geological ages. Finally, technical geological interpretations were deduced.

Discussion

The fracture patterns of south-central Kansas are related to a thickening of the crust, which happens during compression forces. How these fractures are oriented relates to how a major mountain range in western Kansas was formed. This research will contribute to other geological studies in Kansas, encouraging new research.

The age of the fractures is of great importance if the source of the deformational force is to be located. As a result, it is valuable to consider the geologic age of the strata containing the joint system. The same joint pattern is shown to exist in both lower Permian and upper Pennsylvanian geological age rocks. Assuming that the joints are younger than the youngest strata containing the joint pattern, the jointing is at least post-lower Permian in age. Because upper Permian and Cretaceous rocks are absent in eastern Kansas, the latest period during which the joints formed cannot be determined from stratigraphic evidence. This means that, in geologic time during the Cretaceous time period, organic matter would be deposited throughout Kansas and this organic matter would later yield coal and petroleum. The fractures have an opening distance greater than 5cm, and it would benefit the energy industry into looking at fracture stimulation into new oil pool studies.

The jointing also appears to control the existence of Karst Topographies found in the area directly southeast of El Dorado and in northeastern Butler and Cowley counties. 'Karst Topography' is a solution of limestone that can be found along joint surfaces. If produced abundantly, open joints are created, resulting in large caves in this area. An abundance of this solution can make the roofs of these caverns collapse, forming sinkholes. In the sinkholes, many pitted and rounded joint surfaces are present. This research can help farmers and landowners characterize their land for farming and leasing to oil companies.

References

Berendsen, P., and Blair, K. (1986). Subsurface Structural Maps Over the Central North American Rift System (CNARS), Central Kansas. Kansas Geological Survey, Subsurface Geology, and Series 8.

Foley, L. L. (1926). The origin of faults in Creek and Osage counties, Oklahoma. *American Association of Petroleum Geologists Bulletin*, *10*(3), 293-303.

Melton, F. A. (1929). A reconnaissance of the joint systems in the Ouachita Mountains and Central Plains of Oklahoma. *Journal of Geology*, *37*(8), 729-746.

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