D(r)ILL Pickle: An Automatic Pickleball Feeding Machine
(Technical Project)

Enhancing Senior Well-Being Through the Expansion of Pickleball Facilities
(STS Project)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering

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November 29, 2023

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

A quarter of the U.S. population will be 65 or older by the year 2060, with the population of seniors expecting to double from the current 46 million to upwards of 98 million (Mather et al., 2015). The projected rise in the senior population is attributed to the aging of the baby boomer generation, encompassing those who were born during the surge of births immediately following World War II. This statistic highlights the urgency of prioritizing the health and well-being of this community. The baby boomer generation is characterized by its relatively higher educational attainment and extensive work experience, positioning them to enter their senior years with financial stability. Consequently, the primary societal challenge in caring for this demographic focuses on maintaining the well-being of seniors by reorganizing community services to improve accessibility to care and opportunities for physical activity (Knickman & Snell, 2002). The U.S. Department of Health and Human Services claims that although older adults are at a higher risk for chronic health problems, preventative measures could be taken through consistent physical activity (*Older Adults - Healthy People 2030*, n.d.).

One sport that is especially popular among the senior community is pickleball, and it has coincidentally also been the fastest growing sport in the U.S. for the past few years. The 2022 Sports & Fitness Industry report shows that roughly 52% of dedicated pickleball enthusiasts, defined as individuals who engage in the sport at least eight times annually, fall within the 55 and older age category. Furthermore, around 32.7% of these enthusiasts are aged 65 or above (*Older Adults - Healthy People 2030*, n.d.)(Burns, 2022). Additionally, a six-week study done by the American Council on Exercise detail the positive health benefits of playing pickleball in individuals ranging from 40 to 85 in age, concluding “that regular participation in Pickleball elicits cardiovascular and metabolic responses that meet exercise intensity guidelines for improving and maintaining cardiorespiratory fitness” (Dalleck et al., 2018, p. 4).

The objective of my technical project is to capitalize on pickleball's popularity while also encouraging activity among seniors to maintain a stable state of health and well-being. My team will be accomplishing this by designing and prototyping a pickleball machine that shoots pickleballs towards the user from across the court at varying speeds and angles. This training companion serves to help the user improve their pickleball skills, hand-eye coordination, agility, and overall cardiovascular fitness. The primary goal of my technical project is to make solo training more accessible by offering users a training machine equipped with customizable configurations at a lower cost.

Within my STS topic, I will be diving into the roles that policies and healthcare systems play in supporting senior citizens' engagement in racket sports, specifically pickleball, for maintaining good health. I will be framing this sociotechnical issue using the concept of the "sociotechnical imaginary," as guiding with this framework will help explain how future developments around policy and healthcare systems work to promote racket sports for the collective well-being of older generations.

Technical Topic

My team's pickleball machine has been designed with flexibility in mind to help the user hone their skills. The user will be able to adjust the horizontal and vertical launch angle via interacting with the machine's interface. Because this machine was designed with the consideration that most users will be seniors, the interface that will be used to communicate with the machine is relatively simple, with a joystick to toggle between configurations. The specific range of the vertical launch angle will vary from roughly 10º to 60º. This covers shots ranging from groundstrokes to lobs. The horizontal range will allow for pivoting 12º to either the left or the right to cover the span of the court.

In addition to a wide range of ball trajectories, the ball will also be able to travel with different spins and speeds. This will be controlled by a dual-motor launcher. When the top motor spins faster than the bottom motor, the ball will produce a backspin by rotating backwards when launched. When the bottom motor spins faster than the top motor, the ball will be launched with topspin. The relative motor speeds were determined by analyzing the physics of a tennis ball with topspin and backspin (*The Physics of Tennis | Ball Spin In Flight*, n.d.). The speed of the launched ball will vary from around 15 to 50 mph. This is because dinks and lobs are slower and can be taken closer to the net. Groundstrokes will be much faster, clocking in around 20 to 40 mph (*How Fast Does a Pickleball Go?*, 2022).

Another important feature to vary is the rate at which balls are fed. There will be a delay between each ball feed for the user to return the ball and prepare for the next. The motor on the dispensing mechanism will have an adjustable speed on the user interface to allow for balls to be fed every 5 to 10 seconds.

Figure 1a shows the initial design of our machine, and Figure 1b shows the current state of the prototyped machine. Inside the hopper, a spinning disc controlled by a motor will rotate pickleballs into the chute to be launched. Once the ball enters the flexible chute, it will reach the dual motor launching mechanism. The speed of these two motors will control the pickleball launching speed and spin. A linear actuator is mounted on the machine's supports to pivot the machine left and right upon extension and retraction, and the same mechanism was reused to push the frame of the launching mechanism to allow for a vertical pivot. This will enable adjustments to the ball's clearance over the net. This pickleball machine will be compatible with indoor and outdoor pickleballs, and our machine will have a capacity of at least 15 balls. For

portability and convenience, the pickleball machine will be battery powered and can launch the full capacity of pickleballs in the hopper before needing a battery replacement.

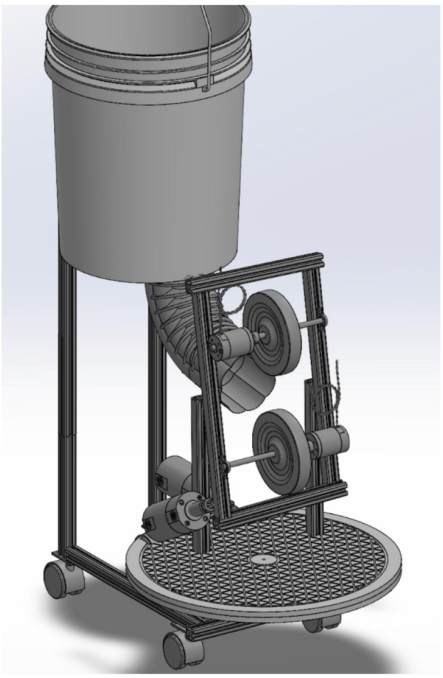

Figure 1a. Design of Pickleball Machine

Figure 1b. Prototype of Pickleball Machine

The design of this pickleball machine will address the introduced problem by encouraging solo training. People may feel discouraged from playing a sport which traditionally requires at least two people when they cannot find a companion, so the goal of this machine is to enable an easy way of staying active with pickleball independently of others.

STS Topic

The baby boomer generation is the longest-living generation in history, so baby boomers have landed a spot at the forefront of a longevity economy. A longevity economy includes "both the products and services [Americans aged 50 and older] purchase directly and the further economic activity this spending generates" (Oxford Economics, 2016). The spending and labor of Americans aged 50 and older supported 88.6 million jobs in 2018, which was 44% of that year's total employment (Terrell, 2019). This challenges a common misconception that aging

negatively affects the growth of the economy, as seniors are still helping drive the nation's workforce through the jobs they hold themselves and also as a consequence of their spending. The Federal Reserve's analysis of the distribution of household wealth within the U.S. show baby boomers accounting for 53.2% of personal net worth as of early 2023 (*Distribution of Household Wealth in the U.S. since 1989*, 2023). Because baby boomers hold substantial economic influence and represent a large demographic of the nation's population, it's important for policies in government and healthcare to be made explicit in supporting the health and well-being of these individuals.

Racket sports, such as pickleball, have been researched to be an ideal exercise which may promote longevity. A study reported in the British Journal of Sports Medicine examined the link between six different types of exercise and the risk of early death (Oja et al., 2017). The study was conducted over a period of nine years and the subjects of the study ranged in age from 30 to 98. The results of the study show that those who regularly played racket sports were 44% less likely to die of any cause. An entry from the Harvard Health Blog also comments on the unique emphasis on the lateral movement involved in racket sports (*Racket Sports Serve up Health Benefits*, 2017). According to Vijay A. Daryanani, a personal trainer associated with Harvard-affiliated Spaulding Outpatient Center, "racket sports force you to move both back and forth *and* side to side. This helps improve balance and weight shifting, which can lower [the] risk of falls" (Daryanani, 2017, as cited in *Racket Sports Serve up Health Benefits*, 2017). Research has shown that racket sports have a notable impact on enhancing the health and overall wellness of senior citizens.

To understand the role of introducing pickleball into senior communities as a part of a desirable future which supports the health of this demographic, I will analyze this through the

lens of the "sociotechnical imaginary." Sociotechnical imaginaries are “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order” (Jasanoff, 2015, p. 4, as cited in Jadowski & Bendor, 2019, p. 542). Imaginaries help explain why certain envisions of social order tend to win support over all other possibilities (“Harvard University Program on Science, Technology & Society,” n.d.). The concept of a sociotechnical imaginary is very subjective, and the determinant of a favorable society is largely dependent on the consensus surrounding the current issues that society is facing and if they are worth addressing.

Connecting the sociotechnical imaginary to the incorporation of pickleball courts within senior communities prompts questions regarding the extent of societal appreciation for the elderly. It’s important to understand what motivates this desirable future and what value lies in the changes to be made. Seniors have been shown to have large economic influence in society, but further research in their importance and value within family and community will help strengthen this motivation. It also encourages reflections on the current barriers seniors may be encountering when engaging in or trying to engage in physical activity, and how changes in policy to improve the accessibility of pickleball facilities can address and overcome these challenges. In my research, I will explore these various aspects to develop a more comprehensive understanding of how improving the accessibility of pickleball contributes to the realization of an ideal future within this sociotechnical framework.

Research Question and Methods

This paper aims to address the following research question: Why is the expansion of pickleball facilities an important part of a desirable future for maintaining the health and well-being of the aging baby boomer generation? Exploring this question is important for

understanding the role of seniors in our society and for evaluating how the concept of a "sociotechnical imaginary" is pertinent to this specific issue. The research methods I will be using include policy analysis and literature review and synthesis. I will aim to limit my research to literature and documents created within the past decade. For policy analysis, I will specifically be looking into policy across cities in America to expand pickleball courts, especially near senior care facilities. Under the method of literature review, I plan to first develop an understanding of the importance of the aging baby boomer generation within America and why it's important to allocate funding to support the health of this community. I will also be researching various studies which support the claim that racket sports are the ideal form of exercise to aid in the health of seniors.

Conclusion

Physical activity is an extremely important part of health, and its significance is only magnified upon entering old age. My technical project is developed with the intention of making pickleball more accessible to solo players. Encouraging exercise via racket sports will help the senior community maintain their well-being over a longer period. Through research of my STS topic, I expect to identify the importance of the aging baby boomer generation and the integral role they play within society. Additionally, I will be conducting extensive research on the effectiveness of pickleball as the ideal sport for seniors. By understanding these two angles, I will be able to explore the sociotechnical imaginary of how future expansion of pickleball courts will facilitate the improvement of seniors' health and why this is important.

Citations

Burns, H. (2022, August 30). *Why Older People Love Pickleball So Much*. Time. https://time.com/6209400/is-pickleball-good-exercise-seniors/

Dalleck, L. C., Smith, L. E., Buchanan, C. A., & Green, D. J. (2018). *The Acute and Chronic Physiological Responses to Pickleball in Middle-aged and Older Adults*. 4.

Distribution of Household Wealth in the U.S. since 1989. (2023). [dataset]. https://www.federalreserve.gov/releases/z1/dataviz/dfa/distribute/chart/#quarter:127;series:Net%20worth;demographic:generation;population:1,3,5,7;units:shares

Harvard University Program on Science, Technology & Society. (n.d.). *The Sociotechnical Imaginaries Project*. Retrieved November 26, 2023, from https://sts.hks.harvard.edu/research/platforms/imaginaries/

How Fast Does a Pickleball Go? (2022, October 4). https://picklevine.com/how-fast-does-a-pickleball-go/

Knickman, J. R., & Snell, E. K. (2002). The 2030 Problem: Caring for Aging Baby Boomers. *Health Services Research*, *37*(4), 849–884. https://doi.org/10.1034/j.1600-0560.2002.56.x

Mather, M., Scommegna, P., & Kilduff, L. (2015). In *Population Bulletin: Aging in the United States* (Vol. 70). https://www.prb.org/resources/fact-sheet-aging-in-the-united-states/

Oja, P., Kelly, P., Pedisic, Z., Titze, S., Bauman, A., Foster, C., Hamer, M., Hillsdon, M., & Stamatakis, E. (2017). Associations of specific types of sports and exercise with all-cause and cardiovascular-disease mortality: A cohort study of 80 306 British adults. *British Journal of Sports Medicine*, *51*(10), 812–817. https://doi.org/10.1136/bjsports-2016-096822

Older Adults—Healthy People 2030. (n.d.). Office of Disease Prevention and Health Promotion. Retrieved November 26, 2023, from https://health.gov/healthypeople/objectives-and-data/browse-objectives/older-adults

Oxford Economics. (2016). *The Longevity Economy*. https://www.oxfordeconomics.com/resource/the-longevity-economy/

Racket sports serve up health benefits. (2017, June 9). Harvard Health. https://www.health.harvard.edu/blog/racket-sports-serve-up-health-benefits-2017060911780

Terrell, K. (2019, December 19). *AARP Study: Americans 50 and Older are Growing Economic Powerhouse*. AARP. https://www.aarp.org/politics-society/advocacy/info-2019/older-americans-economic-impact-growth.html

The Physics of Tennis | Ball Spin In Flight. (n.d.). Retrieved October 25, 2023, from http://ffden-2.phys.uaf.edu/webproj/211_fall_2014/Max_Hesser-Knoll/max_hesserknoll/Slide3.htm