Final Research Paper

Pre-Shot Conditions & Golf Putting Performance Study

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Introduction

Golf is commonly known for its inconsistent nature and ability to get inside the head of the players, directly affecting their performance. This research specifically focused on the results of varying pre-shot conditions on a golf putt. In other words, this study aimed to understand how different conditions can impact a golf putt with the hope of discovering ways to improve how a golfer approaches their shot. We intended for the findings from this research to assist in gaining a better understanding of the psychology of golfers and methods that can be proven to help or hinder the golfer's putting execution on the course. Additionally, we hoped our findings could be utilized in other sporting scenarios to aid future studies, like a basketball free throw for example. The five main components of this study include no practice swing, practice swing, mental imagery, cognitive challenge, and auditory distraction. In the end, this was an interesting study with some telling results giving us a deeper insight into how different conditions and preparation methods behind a golf putt can impact golf performance.

Lit Review

As we conducted our study concerning golf, and in particular golf psychology relating to performance, we set out to find any current literature that was available for us to build our study upon or deviate away from what was already available. As we explored research in our field of interest, we focused on the main themes pertaining to our study. Firstly, sports psychology specifically relates to the area of performance, distraction, and potential anxiety that comes with these changes in routine. Although what is being studied in our case is specific to a golf putt, literature in sports psychology can offer us many insights on how research in sports psychology in regards to golf has developed over previous years. Our second theme would be to focus on golf, specifically putting, and many variations that could play a role in the psychology of the putt. We also found literature on components of our study that had been conducted previously, hoping to pull from these sources. Finally, and perhaps the most paramount component of our study is the literature available for conditions we will be using to test for performance variation. As mentioned in our introduction, these conditions include an auditory distraction, practice putts, a cognitive challenge, no practice, and finally, a form of mental imagery. Throughout this published literature, we could shape and solidify our study to best benefit what we hoped to discover. As expected, there was also literature on conditions that we have chosen not to use ourselves. For the sake of the integrity of our study, we will discuss these as well. The following literature can help us develop new ideas, nudge us in the most efficient direction, and in some cases help refute the generalizability of existing literature.

Sport Psychology

The study of sports psychology is vast and encompasses countless topics and sub-topics. For years, scholars, analysts, and coaches have tried to discover the best and most beneficial

course of action an athlete can take to better their physical performance by caring for their mental performance. This has left us with numerous articles on sports psychology, of which golf is a mainstay. The available research on sports psychology helped us focus our idea specifically on what we hoped to discover. Also noticed, is the fact that sometimes researching one thing in sports psychology, can lead to a discovery in another. For example, Wang et al (2020) set out to find if music before a sporting execution can improve performance, even though this proved to be inconclusive, what was discovered was that music decreased anxiety among the participants. This research has helped us to keep an open mind in our research and to expect to learn things that we perhaps did not intend. Another thing worth noting is that certain areas of sports psychology are far more developed in the literature available to us than others.

As we will discuss in a later section, imagery, for example, is a topic that has been discussed in great depth for decades. As Ely et al (2020) cover, for at least 25 years imagery has been studied within sporting environments. They explain that imagery has been well developed both "theoretically and practically" (p. 14). This research informed us that imagery has been well researched and there is a significant amount of data we can pull from this when we engage in our imagery condition. However, other conditions don't have the same breadth of research available to us. Although focused on golf, we found it important and educational to begin our search with a wider lens. We came across one article that whilst focused on tennis, informed us on sporting distraction and negative thoughts affecting performance. Sille, Turner, and Eubank (2020) dealt with the topic of negative thoughts affecting the performance of a young tennis player. They used REBT (rational emotive behaviour therapy) to aid this athlete in reframing their thoughts to benefit performance. This ended up being a successful way to help with these thoughts. Although negative thoughts are not something our study will focus on, it is important to understand that the

thoughts of the participants are something that may affect results. The more psychological components that we can understand heading into the study the better equipped we will be to understand our results.

Golf & Putting

At this stage we wanted to narrow our focus to golf, and the research that had been published on golf psychology, trying our best to focus on putting when available. This is important to know what is out there already. What are some trends that we can use? What has been proven before and what is their room to explore. Fisher and Fairbrother (2020) covered an important topic that helped us eliminate a certain aspect of our study. Regarding putting, it has been a long-held belief that practicing with a blindfold can improve your results, as you begin to rely on your feelings, over your eyes. What they discovered is that NVT (nonvisual training) does not affect the performance afterward, and in fact, body positioning was more important to performance than visual training. The conditions in this study involved a synthetic putting surface and two groups where one group was blindfolded and the other was not. They suggested switching the groups back and forth to create more realistic results next time, which is a tactic we will adopt.

Golf research can also be mainly physiological and we came across interesting material regarding physiological responses while putting. Filho et al (2021) measured the heart rate, respiration rate, and galvanic skin response when a golfer misses or makes a putt. This article stuck out to us as the studies involved preperformance routines as well as breathing routines that were partook before the putts. Golfers in this study were highly skilled and the heart rate and respiratory rates were not affected dependent on results, but the skin response was. Although

heart and respiratory rates are not something we will capitalize on, learning about the use of the preperformance breathing routines is something that we considered following up on. In 2018, Sato and Laughlin sought to implement a sports psychology course within a classroom setting to test various methods and see how students learned best. They used all four learning modes (experiencing, reflecting, conceptualizing, and experimenting) and concluded that all four methods work for different people, and constant changes will be made to each person to continue getting the best results. This was something we considered for our study, understanding that each condition might be completely different for each participant. We also adopted a variation of the point system used in this article. More specifically, they used a similar scoring system that we will implement where a putt on target generates the most points, decreasing the further away from the hole the putt stops. Before focusing on the specific conditions that our study would entail, encountering research on 'yips' was important for us to understand the literature on the topic. In "An Investigation of the Yips in Golf" (Chambers & Marshall, 2017) they discussed the relationship between perfectionism, anxiety, and putting performance. What they discovered is that there is no significant correlation between a participant's anxiety level and their putting performance. What stood out to us, was their take on the skill level of their participants. "The participants in this study were not professionals, and therefore were unlikely to experience high levels of competitive pressure." (p. 80) This is an important factor to note within our study and is a major reason why we will only be comparing a participant's scores with their own. This research on the broad topic of golf psychology helped us narrow down our intentions and led us to the conditions we ultimately settled on.

Study Conditions

When we began our study by formulating the conditions we would be using with our participants, we had a wide array of ideas that we wanted to narrow down to four or five that would result in the most conclusive evidence. After extensive research, we settled on our five, as discussed in our introduction and methods portions. The following articles are examples of research already completed that helped or informed us on some of our chosen conditions.

Pre-Shot Practice

One of the conditions that our participants will exhibit is not being allowed to take a practice stroke before their stroke, as well as a separate condition being the practice stroke before hitting the ball. In an article by Hasegawa, Miura & Fujii (2020) the concept of a practice shot was put to the test. In this study, there were three conditions, including practice shot, real shot, and no practice shot. The practice shot and real shot were to the same distance, and for the one with no practice shot, they changed the distance. Perhaps as expected, the groups with a practice swing resulted in a better performance. This article helped strengthen our pre-study assumption, that the practice shot has a high possibility of being the most successful condition, which was an incorrect hypothesis ultimately. Further research on practice strokes also split their participants into three separate groups. One would be told to practice the same way each time (blocked practice), one could practice how they want (random), and one couldn't practice. Ultimately, the group with autonomy ended up with a higher performance (Fazeli et al, 2017). In our study, the practice shot condition and the practice swing were performed how they prefer to, making it more random. We originally believed that this fact, paired with one of the conditions being a practice stroke should lead to more consistent results amongst our participants.

Auditory Distraction

Another condition we settled on was providing an auditory distraction before the putt took place. One of the reasons we wanted to focus on this as one of our conditions was because of the assumption that this would be detrimental to performance. However, we came across the following article by Herrebrøden et al (2017): *Are Auditory Distractions Disturbing and Detrimental to the Performance of Expert Golfers? A Field Experiment.* This challenged our assumption and concluded that auditory distractions aren't necessarily negative for performance. However, they also added that "expert golfers who are aware of research suggesting that they can cope with auditory distractions due to their advanced skills might be able to perform more confidently when auditory distractions are present". (p. 334). This is something that we will challenge as with our random conditions and varying levels of athletes, this should not be something we have to compete with. Gal Ziv (2016) when studying putting performance in his study had a few takeaways after the fact. He suggested that in "future studies they use counterbalance designs, and in addition implement more realistic auditory and/or visual distractions." (p. 80). This inspired us to focus on their idea of realistic auditory noises you would hear at a golf course. This included cheering, yelling "four", birds chirping, and aggressive sounds of drivers hitting a ball off a tee. This is considered realistic auditory because it is audio you would typically hear on the golf course.

Imagery

Imagery has become a large part of competitive sports, doing it correctly can have a positive impact on athletes' performances. This is especially true for sports like golf when the athlete has time to approach their shot and often a lot of pressure to make that shot a good one.

Brouziyne and Molinaro (2005) believed that imagery could have a positive impact on golf performance, even for beginners. In their study, they put participants into three groups containing one that used regular golf practice techniques, one combining physical practice with imagery practice, and one that did nothing. As expected, the group combining physical practice with imagery had significant improvements in results for beginners. This helped design our study as most participants were at the beginner to amateur level and should be able to adopt some of the imagery success seen in Brouziyne and Molinaro's findings.

In a different study, Barker et al (2018) found that eye movement desensitization and reprocessing could help with golfers' focus and anxiety in their performances. This was helpful in our study by properly assisting our participants to use imagery and get the benefits of it in their performance during this condition of the study. More specifically, a study by Chwasky and Tomasi (2014), found how golfers can use the method they called the "Third Eye" in which players would retain a mental image of the target they're aiming at after they shift their focus back onto the ball. This was helpful for setting up the imagery, visualization techniques throughout our study and appeared to be relatively effective.

In another study that found opposing results by Taylor and Shaw (2002), they had golfers putting with no imagery, positive imagery, and negative imagery. Meaning, one condition they just putt normally, one they would imagine themselves doing well and scoring high (positive imagery) and then imagine missing their shot and screwing up (negative imagery). In their findings, they revealed that negative imagery was detrimental to the performance of the putt, but positive imagery and the control group showed no significant difference. This is important to include because while most findings showed a positive result when using imagery, this study seems to think it made no difference, leaving room for us to add more findings into their

category of research as we did conclude that the positive imagery was overall positive in this research design.

In a study by Ploszay et al (2006), they found that while imagery did have some positive impact on their participants, it was not significant, meaning it had a *P-value* greater than 0.05. However, it was important to note that in this study no participants harmed their results in the imagery trials. Additionally, there was only one participant with prior experience with imagery and still no negative impact. This was interesting to compare to our findings as we expected imagery to also have no negative impact and be more positive in performance with a group that also has little to no experience with imagery. However, in the end, we had very similar findings to Ploszay et al as the imagery was not negative but was also not significant either.

PETTLEP is a known method for imagery, which is an acronym for physical, environment, task, timing, learning, emotion, and perspective. This model tries to make imagery as realistic as possible and in the study by Swainston et al (2012), they found it to be useful. They had participants take a golf swing using this PETTLEP method before and after their pre-shot routine. They did see an overall increase in performance than before using the method but there was no difference between the two times, they would use this imagery technique. This is telling because if there was a significant increase in performance in the after-pre-shot routine then this could have been when we might have considered using the imagery instead and adding a pre-shot routine to the imagery condition. In the final imagery study, we found, Ramsey et al (2008) discussed the differences in putting with facilitative imagery compared to debilitative imagery and no imagery. Facilitative imagery means it is designed to facilitate a positive effect to learn and perform. Whereas debilitative imagery was there to enforce a negative effect on individuals' abilities to learn and perform. The research found that facilitative imagery did have

the most successful results with the participants putting, so we did focus on using the facilitative imagery approach in our study for the most significant impact on the results.

Omitted Conditions

As previously stated, the amount of literature available per condition was widely varied. One of our conditions will be producing some sort of cognitive challenge for the participant to complete right before they take their shot. We did this by asking a simple question for the participant to answer while they take their shot and be distracted by this, which will all be elaborated on more in the 'methods'. This is something that lacks literature of a similar nature and is a hole we are hoping to fill within our study. The other aspect worth noting is conditions that have been completed in other studies that we are choosing not to use for one reason or another. Whitehead and Jackman conducted a golf study in 2021 where they would use a TA (think aloud) approach before the shots. They concluded that taking a pre-shot routine one step further and vocalizing thoughts could improve performance. We opted against this as our participants might have varying levels of confidence or comfortability to do this for our study.

Another potential condition is the practice of breathing techniques. A study that we have previously written about (Filho et al., 2021.) used breathing techniques as a variable to measure the putting success. In their study, they discussed how skilled golfers would have more experience with breathing routines and would most likely have one factored into their pre-shot routine already (p. 79). We chose to omit this as we don't want our experienced participants to feel as though this is a waste of a condition and perhaps not giving us significant results. In a separate article by An et al, 2020, the conductors let their participants choose which condition they would do, and how they would do it. As anticipated, when given a choice, the performance

increased. This was another option, but ultimately, we decided this would undermine our randomization tactic to create more realistic results.

Finally, in a study by Fulton et al (2014) visual distractions were used to test ‘quiet eye time’ amongst golfers. Essentially, this is the time that athletes use before a certain motor task where they look at a certain thing (in a golfers' case it will be the ball) before making the shot. What was found was that even though the distraction didn’t harm the performance, when quiet eye time was increased it can make an impact. This was the reason that we opted for an auditory distraction over a visual one. We did not want to allow for a significant time between distraction to shot execution, so much so that the condition would have been made redundant.

Study Components

Two components of our study that we hoped to garner research on were the skill level of the participants of our study, and the use of a post-study questionnaire to gather the perceived difficulty of the varying conditions. Let us start with the former. A study mentioned previously (Fisher & Fairbrother, 2020), discussed the participant levels in their study. They studied both intermediate golfers and novice golfers to gather results. This technique was furthered by Yumiko et al (2020) who also gathered results from professionals and amateurs, citing those results were more noticeable among amateurs. In our study, having participants of all levels should allow us to see more significant results. Although participants will just be comparing their results to themselves and we also will be providing the questionnaire to our participants. Chambers and Marshall (2017) used a questionnaire to measure certain levels of anxiety and perfectionism amongst their participants. They then compared the questionnaire results with

what they saw in the physical portion of the study. This is a similar comparison style questionnaire we employed in our study to further our interpretation of the results.

The discussed literature helped us develop new ideas, nudged us in the most efficient direction, and in some cases, helped refute the generalizability of existing literature. As mentioned, some aspects of our study have been researched greatly while some leave more room to explore. This literature has encouraged us in the direction of our study to ultimately understand if a specific pre-shot condition can prove overwhelmingly beneficial for a golfer.

Methods

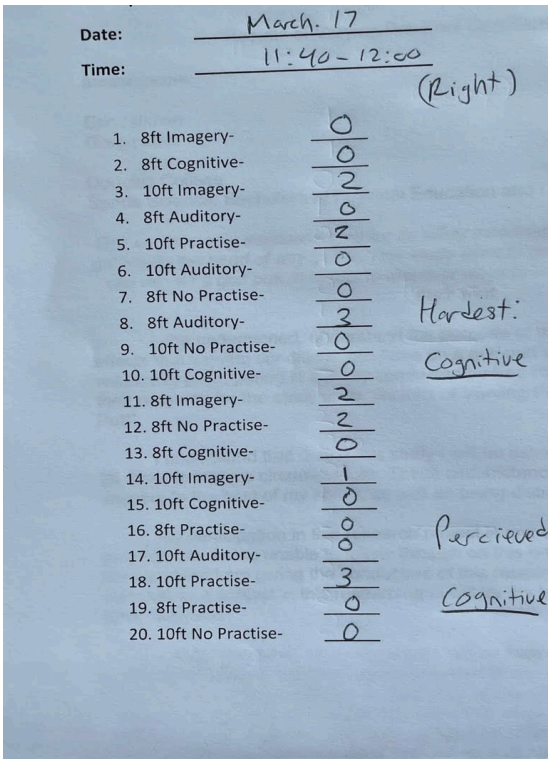
Through mixed methods research we conducted a study analyzing the different conditions affecting a golf putt for amateur golfers in a controlled environment. Participants were recruited through specific selection as we wanted individuals with some golf experience but of any gender or age. Before the research day, the participants received information on a general idea of what to expect from their experience in the study. As participants came into the study room at their scheduled time slot to collect their data, they received a consent form outlining everything we planned to do with their information and giving them the option to opt out of the study at any point or keep their data anonymous. There was also a separate spot to consent to have their photo taken during the data collection process. From there, one participant would go through the study individually one at a time undergoing four putts for each of the five different conditions.

When conducting the study, participants would putt using five different conditions, to mention for one more time this included a putt with a practice swing, no practice swing, mental imagery, a cognitive challenge, and an auditory distraction. Each participant performed all five conditions four times each, resulting in twenty attempts altogether. We chose four putts so we could see each condition more than once and also more than once on both the 8ft line and the 10ft line as well, resulting in four total per each condition. When conducting this study, it was important to have a very controlled environment so the repetitions are kept consistent and controlled. Being indoors allowed for the study to have no varying weather conditions which is why this took place in the sports science lab on the Douglas College campus. When performing the five conditions each participant performed four attempts of each condition at a set distance. Per condition, the participant would be instructed to hit twice from an 8ft line and twice from a

10ft line for their four attempts on that condition. This would result in a total of ten shots from the 10ft line and ten shots from the 8ft line. This same format occurred for each condition twice, but we randomized the order for each participant across all twenty shots. In figure 1, the datasheet we used to collect all the results can be seen below.

Figure 1

This is an example of a filled-out data collection sheet we used. Outlining the randomization used across all five conditions and the two different distances.

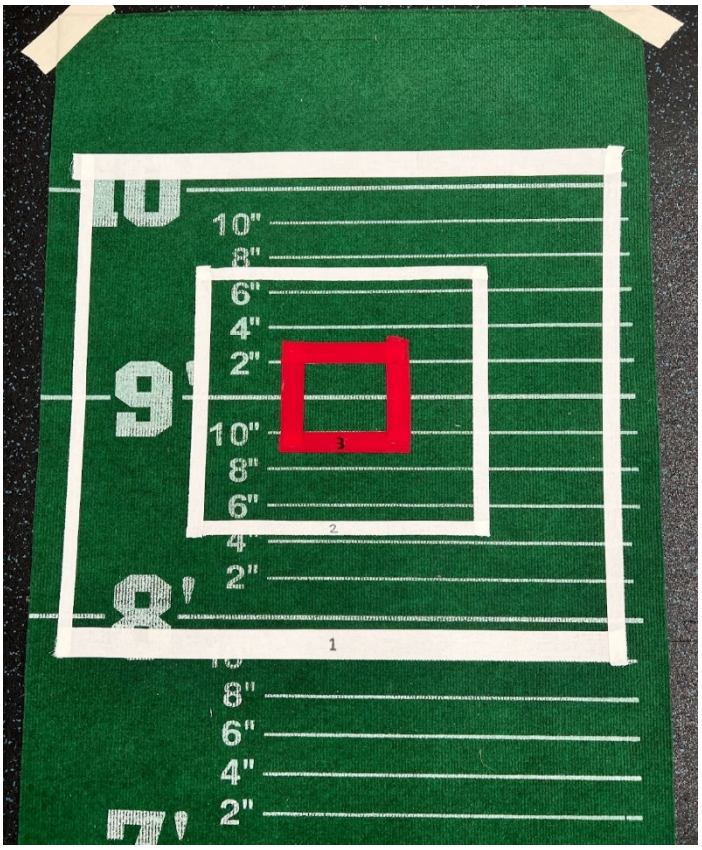


Note. The "Right" represents the handiness of that specific participant.

Once the distance was set and the condition was ready each participant would be aiming to hit the middle of a target similar to throwing a rock in curling, but each ring (square) will represent a point, with the center being the highest score (see figure 2).

Figure 2

The target boxes each participant will be aiming for to collect the data for this study, this is the basis of how each participant will score points (0-3).



As seen in figure 2, the centermost box is the main target with the highest score of three points, the next box is worth two points, the outermost box is worth one point, and anything that is outside all boxes being too short of a putt, too long, or hit wide, will result in a score of zero. The participants' scores in each condition were compared to their own performances to see how each condition impacted the results of that individual. Comparing their score to themselves, rather than other participants, which results in more accurate outcomes, as compared to other

participants of differing golfing abilities would be misleading. During the study, the same ball was used for each participant and there was a single ambidextrous putter available for all participants to use, as there were both left and right-handed individuals used in this study. There was a total of eleven participants used in this study, all being college students in their twenties, with varying golf experience, being mostly amateurs to beginners and no professionals. At the end of the study, there was a short questionnaire for each participant as mentioned earlier. In the questionnaire, they simply answered which condition they perceived to be the most challenging and which one was the easiest, which was then compared to their actual results. We wanted to know how they perceived the condition despite their results, to know how they personally felt as though the condition made an impact on their shot. This was in hopes to make the conditions have more credibility on top of the data results.

Conditions

The five conditions are the main components of this research study so it is important to break each one down for a better understanding. All conditions are mentioned above. For imagery, we had participants line up their putter at the ball ready to shoot with no practice swing or movement. From here, we would walk them through a short mental imagery exercise which included visualization and breathing techniques before taking their shot. They were instructed to focus on their breathing and then will then look at the target and burn an image into their mind of themselves hitting the ball perfectly into the target. They would then see the target line they wanted to the bullseye and then close their eyes and visualize themselves making perfect contact with the ball to get a high score. Finally, they will open their eyes and take the shot immediately after using the imagery techniques.

Another condition participants used was the cognitive challenge. With this task, the focus was to see how distracting thoughts in the participant's mind would impact their ability to perform. We thought this could be more challenging as the participants will have their focus pulled away from the ball and on the question we ask. However, because golf is such a mental sport, we thought it could also benefit some by not overthinking their shot success, which will be revisited in the discussion portion to come. In this condition, the researchers asked the participant a standard question right before they shoot. As we finished the question, they would start to take the shot and had to answer it as they connected with the ball for their shot. We asked simple straightforward questions such as "what year of college are you currently in?" or "what is your favourite type of animal?". These questions should be able to be recalled fairly easily but would require a moment of little thought but enough to require their focus to shift. It is important to note here that we also double-checked the authenticity of their answer. If they provide a false answer, we would void the result of that following putt and reshoot with a different question. The reason this is important and relevant is that there are times on the golf course your group might be talking around you and you may have thoughts in your head taking your focus away from your shot, as mentioned prior.

The next condition was an auditory distraction, this simply required the participants to take their shot while the researchers played loud audio directly behind them through a speaker. While participants made their shots, they would hear loud noises and sounds you would hear while golfing, mostly the sounds of loud drivers hitting balls, "boos", and chirping birds. This made it more challenging to focus on the shot for the participants and acted as a distraction, which can always occur on the golf course mid-shot. The audio gathered for this distraction was all clips of sound pulled directly from golf course footage sound effects.

The fourth condition was to simply make a regular putt with no distractions or anything to think about but the only catch is they will be required to not take a practice swing for this shot. In this condition, participants would just step up to the ball and make their shot right away. The thought behind this is how sometimes golfers can get too into their heads when taking a lot of practice swings and preparation for their shot. We predicted that hitting the ball right away could benefit some because it would eliminate the pressure and overthinking of the shot. However, we also thought it could be more challenging for some participants, in the end, this was surprisingly the most successful condition score of all five.

The final condition was a regular putt again but this time participants were allowed to take a practice swing. A typical golf practice swing does not allow for you to touch the ball in any way, but rather just get a feel for the swing and better the chances of a smooth shot. In theory, this is supposed to aid the golfer on the course, and in this study, it gives a golfer more time to prepare their shot and practice their weight and speed of a shot. We allowed each participant to do whatever they liked to prepare for the practice swing as long as they did not make contact with the ball. For some participants, we had to direct them and assist in some good techniques for executing the practice swing. Those are the five conditions participants experienced throughout the study.

Research Methods

There were a variety of research methods used in this study which were mentioned earlier, including mixed methods, randomization, and questionnaires. Mixed methods was used because most of our data was collected through a very quantitative form of research, but there was also be an aspect of qualitative research in our questionnaire at the end of the data collection

for the participants as mentioned previously. To make this study very controlled for collecting the data we used randomization for the different conditions. Furthermore, we thought that if each condition would be performed one at a time in the same order, participants would naturally shoot a higher score near the end just from familiarity with that condition by getting into a rhythm. With this in mind, we decided to make the four shots for all five conditions completely randomized throughout the total of twenty shots. Beyond our questionnaire for collecting data, we used the actual golf putt results to gather most of our findings, as this is what revealed how much the conditions impacted the quality of golf putt. To measure the accuracy of the shots we had the participants aim for a target bullseye style system. Similar to curling with the target rings, or a dartboard, there will be lines taped flat to the ground forming squares which can be seen in Figure 2 mentioned earlier. The outermost ring (square) had a total perimeter of 104", followed by 64", then the bullseye was a total of 24". Due to the floor in the Sports Science lab allowing for the ball to roll uncontrollably, we used a flat mat with a carpeted material that can closely simulate the short smooth grass on a golf green. In the end, we had participants take four shots with each of the five conditions between both the 8ft and 10ft line and then recorded the number of points they scored per shot. This allowed us to collect plenty of results regarding averages in each condition, and learn more about which conditions were easier and harder.

Results

The purpose of this study was to distinguish the effect of differing pre-shot conditions on the result of a golf putt. We were able to extrapolate various forms of graphs and charts to show the results of this pre-study question. The selection of particularly revealing data is shown in the following section.

Our Predictions

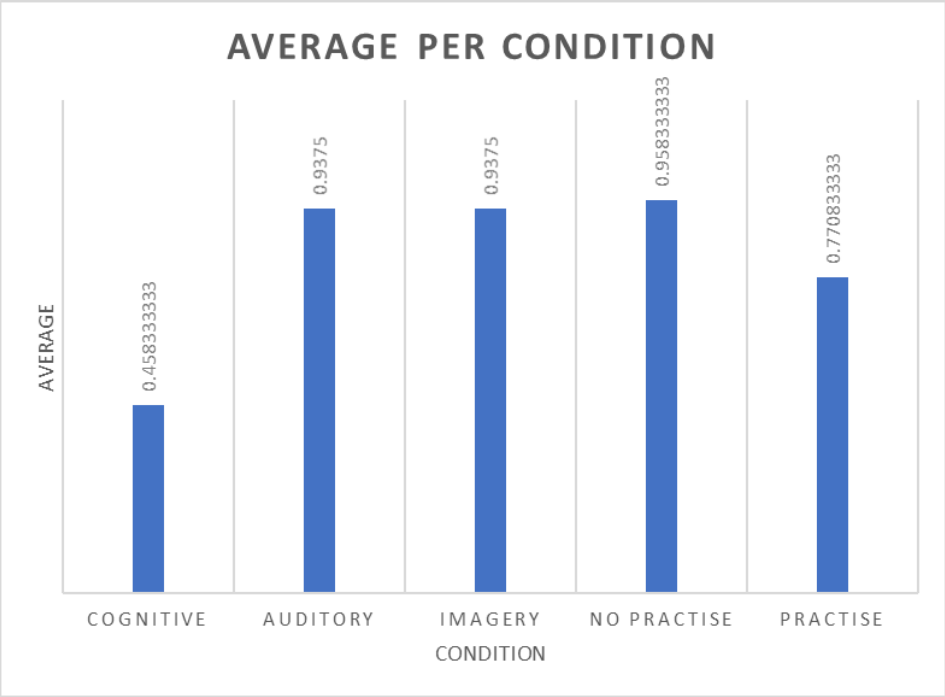
Prior to collecting data for this study, we hypothesized that of all the conditions both imagery and practice swing shots would score the highest amongst the participants. This would mean that these conditions would have the most positive impact on the participants' results. On the other hand, this suggests that we anticipated the cognitive challenge, no practice swing, and auditory distraction to be the most challenging for the participants, making a more negative result on their data. We will explore the data collected and take a deeper dive into the results and what we learned in the following sections.

Condition Average

This bar graph shows the average score of each condition across every participant. The score could either be 0, 1, 2, or 3 and the average is represented above each bar.

Figure 3

Average scores across all five conditions

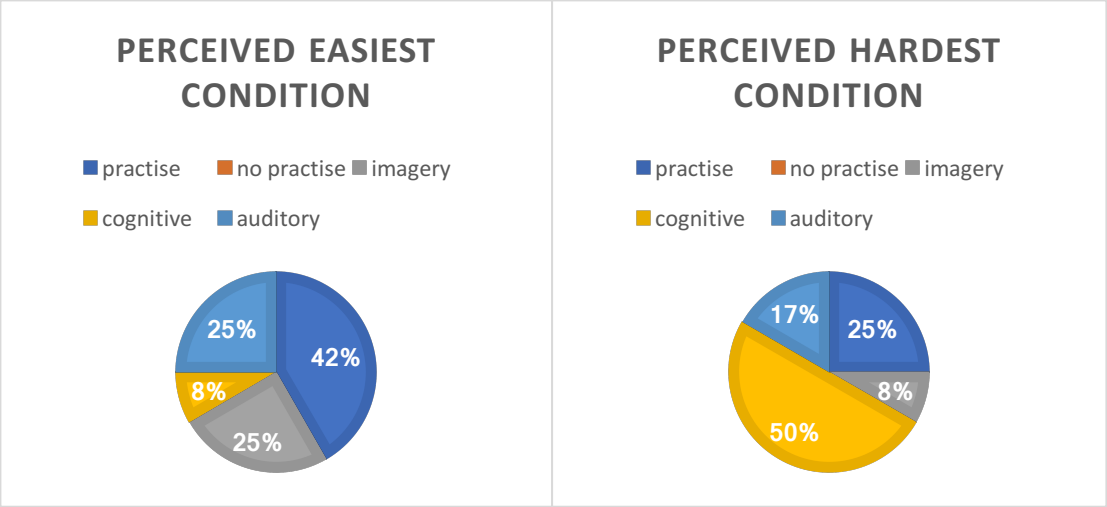


Subjects' Perception of Conditions

After each subject completed their 20 shots, we asked them what they found to be the hardest condition, as well as what they found to be the easiest. It is important to note that the question was not asking about what they thought they did best at. These two charts show the distribution of answers to these questions.

Figure 4

Perceived Condition Difficulties



Note. The easiest perceived condition pie chart (left) had practiced as the highest while the hardest perceived condition (right) was the cognitive condition.

Condition vs. Condition

We tested five conditions and compared them against each of the other conditions. This meant running ten single factor ANOVAs to make the table below. It shows the results of each condition as well as the P-value for each comparison. Three comparisons returned significant P-value scores.

Table 1

ANOVA Comparisons

Conditions			Difference	P-Score	Significant?
Practice	*vs.*	*No Practice*	9	0.39881	NO
Practice	*vs.*	*Cognitive*	15	0.121848	NO
Practice	*vs.*	*Imagery*	8	0.454894	NO
Practice	*vs.*	*Auditory*	8	0.458891	NO
No Practice	***vs.***	***Cognitive***	**24**	**0.011011**	**YES**
No Practice	*vs.*	*Imagery*	1	0.923176	NO
No Practice	*vs.*	*Auditory*	1	0.923897	NO
Cognitive	***vs.***	***Imagery***	**23**	**0.015214**	**YES**
Cognitive	***vs.***	***Auditory***	**23**	**0.016397**	**YES**
Imagery	*vs.*	*Auditory*	0	1	NO

Significant ANOVAs

In reference to the table above, here are the results of the 3 single factor ANOVAs that gave us a P-value of <0.05.

No Practice vs. Cognitive

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
NO PRACTISE	48	46	0.958333	1.10461
COGNITIVE	48	22	0.458333	0.679078

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6	1	6	6.727634	0.011011	3.942303
Within Groups	83.83333	94	0.891844			
Total	89.83333	95				

Cognitive vs. Imagery

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
COGNITIVE	48	22	0.458333	0.679078
IMAGERY	48	45	0.9375	1.12367

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.510417	1	5.510417	6.113351	0.015214	3.942303
Within Groups	84.72917	94	0.901374			
Total	90.23958	95				

Cognitive vs. Auditory

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
COGNITIVE	48	22	0.458333	0.679078
AUDITORY	48	45	0.9375	1.166223

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.510417	1	5.510417	5.972376	0.016397	3.942303
Within Groups	86.72917	94	0.922651			
Total	92.23958	95				

Discussion

The rationale behind the five conditions used was to cover both physical and psychological influences that could impact the success of a putt. ‘Practice’ and ‘No Practice’ covered the physical aspects, while ‘Auditory’, ‘Imagery’ and ‘Cognitive’ covered the psychological. Despite these conditions representing either physical or psychological conditions, the relationship between the two types is seen across all conditions. For example ‘practice’ proved to be more challenging than expected arguably due to the added psychological restrains participants unexpectedly experienced here. Based off of our chosen scoring system and complete randomization of conditions, the clearest way to discuss results was using the average score of each condition, as well as comparing every condition to one another. This way we could tell if certain conditions were significantly detrimental to a pre-shot routine for a golfer, or significantly helpful. In this discussion section, we will break down our findings and come to conclusions using our analyzed data.

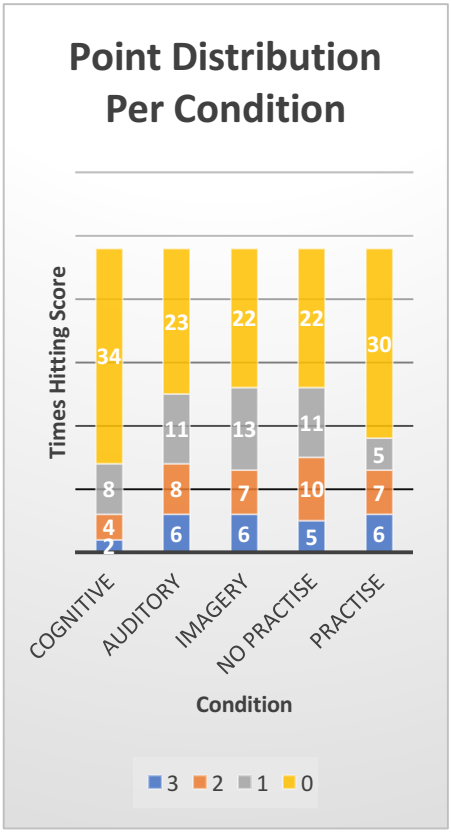
Averages of Conditions

If we refer back to the bar graph representing the condition averages in the result section, we can see that there were three conditions that all presented near identical results. Auditory and Imagery both provided an average of 0.9375 while No Practice provided an average of 0.9583, which was the highest among the five conditions. The practice condition was slightly lower than the previous three at 0.7708 and our Cognitive condition was much lower, posting an average of 0.4583.

What Do These Averages Mean?

As mentioned in our methods section, each putt could result in either a score of 0, 1, 2, or 3, depending on how close the ball got to the center square. The averages in Figure 3 can tell us that most shots resulted in either a 0 or a 1. Figure 5 shows the distribution of points among all five conditions. As cognitive had the lowest average, it makes sense that 34 of the 48 putts taken within the cognitive condition resulted in a 0. Interestingly, although Auditory, Imagery, and No Practice had very similar averages, their point distribution was also almost identical.

Figure 5: *Point Distribution*



Why Each Conditions Average is Important to us

By looking at the results of each condition, we were able to justify using that condition to tell us the information that we were hoping to accomplish during this study.

Practice and No Practice.

'Practice' and 'no practice' were in there as our physical conditions. Having a 'practice' condition was as close to a control condition we could've had, as we allowed the subjects to address the ball however they liked and practice their swing to their personal preference. Pre-study anticipation was that this would result in one of the higher tested conditions. This was not the case as it was in fact our second lowest. One reason for this may be because of the level of our participants. If the participant does not have much golfing experience, they may not have their own practice technique that would help them in this case. Additionally, we believe that with

the less experienced golfers, the more the practice condition was actually adding a psychological effect, getting inside their heads making a more negative impact on their results. On the opposite side, we expected ‘no practice’ to be one of our lowest scored conditions, and it ended up being our highest-scoring condition. We believe this may be because of a similar reason, with ‘no practice’ not giving the participants a chance to overthink their shot before executing it. The level of participations skill will be discussed in our limitations section.

Imagery and Auditory.

‘Imagery’ and ‘auditory’ scored identical averages over the course of our data collection. This was interesting as imagery was supposed to aid in lowering performance anxiety and improve performance while auditory was intended to be a distraction. A common theme throughout our analysis was that distractions weren't always perceived as negatives among our participants. Some mentioned that being distracted by another source actually took off the pressure of the task at hand, which was to complete a successful putt. This will be explored more in our section where we look at our participant's perceptions. Although both conditions returned an overall average of 0.9375, what is interesting is the average of the first shot under each condition. Taking only the first shot into consideration, the average for Imagery was 1.0833 whereas the first shot average of the auditory condition was 0.6666. This tells us that the auditory condition had much more of a distracting result when they first heard it and were perhaps surprised by it. The average increasing throughout the trials can tell us that they got used to the distraction, and perhaps channeled it to be a positive for their performance.

Cognitive.

As mentioned, the 'cognitive' condition had a much lower average than the others. Pre-study this was anticipated, as we knew the golfer's focus would be taken away from the task at hand during this condition. In fact, only twice did a participant score a 3 while under this cognitive condition. As will be discussed at greater length in our limitations section, coming up with a cognitive challenge was challenging in itself, in terms of using one that could potentially be realistic to a real golfer in a real game situation. The purpose of sticking with a cognitive challenge as one of our conditions was to highlight the fact that golfers will often have other matters on their mind besides golf. The cognitive challenge was intended to show us what effect this has on performance when the participant's mind is actively elsewhere. Through this average and following test scores, we can see that having the golfer's mind exclusively set on their shot is highly beneficial.

Significant Tests

Our alternative hypothesis was that different pre-shot conditions would affect the success of a putt when placed upon a golfer. Therefore, our null hypothesis was that the condition would not affect the success rate of a putt. With our five conditions, we ran single factor ANOVAs for every comparison, coming to ten in total. The results can be seen in 'Table 1' in our results section. In any scenario, a P-value of < 0.05 would have indicated statistical significance for us (McLeod, 2019). We achieved this on three occasions. This gives us strong evidence against the null hypothesis in those three scenarios. More detail on these three ANOVA runs can be seen in our results section. All three significant results included our cognitive condition against another, those being auditory, no practice, and imagery. Interestingly, comparing our cognitive condition against the others is what provided us with significant P-values. Because of this, we can say that

placing this cognitive challenge condition on the participants made a significant difference in their ability to score well during our study. ‘practice’ vs. ‘cognitive’ was the only matchup including cognitive that did not have a P-value score of < 0.05

Non-Significant Tests

This means that seven of the ten comparisons returned P-values > 0.05 and therefore we retain our null hypothesis and reject our alternative hypothesis on these counts. Having such high P-values on many of these comparisons was to be expected. We knew that in some cases we might not see our conditions produce largely differing results from one another and this was the case. For example, as we had mentioned previously, our 'auditory', 'imagery', and 'no practice’ conditions all had very similar averages, therefore producing higher P-values. In fact, our auditory vs. imagery ANOVA retuned a P-value of 1.

Why Were So Many Not Significant?

Even though the majority of our comparisons weren’t statistically significant, there was still variation in the scoring of each condition. But why were so many not significant? Well, as we had anticipated, golf can be a wildly random and unpredictable sport. So many factors come into the success of a golf shot, let alone an entire round, some of which will be discussed in limitations. Pre-study, we knew there was a large chance that many comparisons would show smaller variations. On top of our conditions there are additional factors including individual skill, personality type, performance under pressure, and lucky shots, just to name a few.

Perception vs. Reality

Although we had and have broken down the results of what condition resulted in the best performance. We found it important to ask our participants what condition they thought were the

easiest and which condition they found the hardest, thinking specifically about how their overall experience was while trying to hit a ball during that condition. One of the reasons for this was to show that sometimes golfers will have a pre-shot habit that they think works for themselves but might not be resulting in the best outcome. We made it clear that we were asking what they found the "easiest" and "hardest" and not the "best" or "worst" in order to get their true opinion. Refer back to figure 4 to see the results of this questionnaire. We also believed this to be an effective tool of measurement because as previously stated golf is full of surprises and sometimes you even get a good shot by luck. In this case, if a participant had a lucky shot the data would show that the condition helped them when in reality, they might have still selected that condition's experience overall to be the most challenging.

Easiest Perceived Condition

Prior to the study, the condition we anticipated to result in the best scores was the 'practice' condition. Interestingly, it was the fourth most successful condition out of five, being quite opposite to our pre-study guess. Participants also perceived having a practice before their shot as the easiest, with the highest vote of 42% of participants selecting it as their easiest even though it scored poorly. This could be because of their perceived control over the pre-shot routine. By having the autonomy to do what they wanted to before shooting might've seemed easiest to them, although the result was more revealing of the truth. Other conditions of this study like 'auditory' and 'imagery' scored the same, at 25% of the votes each. Most intriguing is that 'no practice' got 0% of the votes for easiest perception, although it was the highest score in the condition. Again, this could come down to perceived control over the pre-shot routine.

Hardest Perceived Condition

The hardest perceived condition had results more consistent with what the results told us. In fact, 50% of all participants agreed with the data that established the 'cognitive' condition as the most difficult. This was expected, as it was the one condition that took the participant's attention away from the putt itself. Once again, 0% of participants chose ‘no practice’ as the hardest, meaning it was never voted for as the easiest or hardest condition.

Limitations

Before the study took place, we had identified some areas that might act as limitations to our study or impede the validation of our results. During or after our study dispelled some of these limitations but also highlighted a couple that are worth noting.

Skill Level of Golfers

We knew heading into our study that we would get participants of varying skill levels in regard to golf. We welcomed this as we believed this would’ve given us a richer variety of data. This was mostly the case. However, if the majority of participants were considered higher level golfers, we believe we might have seen a change in the physical conditions, as more skilled golfers might’ve been disposed to benefiting more from our ‘practice’ condition and struggling with the ‘no practice’ condition. In the future, purposeful sampling of skilled golfers could help us gather information truer than that of a non practicing golfer.

Distance of Putts

Due to the nature of our putting surface, our putts were either from 8 feet or 10 feet to the center of the target. Originally, we had planned to have a longer putt, but our putting surface did

not allow for this. By only having shorter distances, it could've made putting too easy to see the true nature of our conditions. This shorter difference potentially allowed for subjects to get 'lucky' more often than if the distance was increased. However, plenty of participants still did struggle even with the shorter 8-foot distance, so perhaps our original idea to have something beyond 10 feet may have not been as good of a result anyways. Thankfully, due to everyone putting from this same distance, the averages would have been consistent across the study.

Delivery of Imagery Condition

Because the conditions were randomized completely, it meant our imagery condition would occur at different points of the study for different participants. If someone's imagery was their very first shot, the script would have sounded slightly different than if their first imagery fell during their 11th shot for example. Because of the randomization of our conditions, the imagery scripts would have been indirectly affected. This could've changed the effect that our imagery condition had on varying participants.

Cognitive Condition

This has been mentioned and justified throughout the process of our study, but designing the cognitive condition was one that was challenged and revised throughout the planning. When we finally settled on the concept of asking our participants a random, easy question before their shot we knew it wasn't going to be something they would directly deal with on the golf course. This was a limitation in our study because we knew that it would be a stretch from a cognitive issue that they would have in a real-life situation. However, what our cognitive condition ended up being was an exaggerated extension of what a golfer will deal with on the putting green, which is thinking of non-golf related issues in their life that may distract them or affect their

performance. If we had a way to distract their thoughts more realistically and be able to measure them, we would've, but we acknowledge this condition was a limitation to our study.

Conclusion

In the end, this was a very enjoyable and engaging study for both the participants and the researchers. Emerging from collecting data and being surprised by what you find can make the research especially interesting. For example, some big takeaways were how no participants found the 'no practice' condition to be easy despite it actually being the highest-scoring condition. Additionally, the fact that the majority of participants found the 'practice' condition to be the hardest one was really interesting as we would have never suspected this before conducting our data.

Entering into this study, we hypothesized that pre-shot conditions would have an effect on the success of a putt. Because of the nature of our study, and the various conditions, we were able to run ten single factor ANOVA's. On three separate occasions, we were able to reject the null hypothesis. On seven occasions, we couldn't. These were the anticipated results. Some conditions will have significant effects, while others wont.

Ultimately, this study can show how much impact individuals' own thoughts and mental processes can impact their performance in a sport like golf. Furthermore, this study also tells us that at times people perceive their levels of success or failure differently from how well they actually did. This can tell us that in sports some people might find certain things really impact their abilities to succeed when in reality that was not the main factor in their decline in performance.

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