UNITED STATES MILITARY ACADEMY

DYNAVISION D2: ESTABLISHING A PERFORMANCE BASELINE FOR PERIPHERAL AWARENESS

PL490: ENGINEERING PSYCHOLOGY

SECTION C

LTC JAMES MERLO

BY

CADET ADAM LARY '10, CO E2
CADET MATTHEW NULK '10, CO D1
CADET WILLIAM SCHUH '10, CO E2

WEST POINT, NEW YORK

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Dynavision D2: Enhancing Visuomotor Skills

Adam H. Lary

Matthew P. Nulk

William E. Schuh

United States Military Academy

Abstract

In today's operational environment in Iraq and Afghanistan, peripheral vision is critical as soldiers must have complete awareness of their surroundings. Thus, methods to improve peripheral vision and awareness could be extremely beneficial to the military population. The Dynavision D2 claims that it can improve visuomotor skills and peripheral awareness to improve performance of athletes and patients with visual problems. The D2 has already seen limited use in training military personnel as well, but this program has the potential for expansion. Our research goal is three-fold: 1) to analyze a possible way to improve peripheral awareness and reaction time 2) to determine the "learning curve" for training on the D2 with a fixed training program among military personnel and 3) to establish a performance baseline for D2 users to establish a benchmark for comparison. We hypothesize that peripheral awareness will increase through training on the D2 with six or fewer training sessions required to overcome the learning curve.

Dynavision D2: Enhancing Visuomotor Skills

Literature Review

In the streets of Baghdad, a soldier on patrol walks past a crowded market. As dozens of Iraqi civilians walk and drive by conducting their daily activities, the soldier must scan each for a number of threats: suspicious activity, concealed weapons, wires, low-riding vehicles, cell phones, etc. Simultaneously, he must search the surrounding rooftops and windows for signs of potential snipers and where he can find cover if necessary. In all of these tasks, peripheral vision plays a key role—perhaps the soldier identifies the muzzle flash from a sniper rifle out of the corner of his eye or a sudden movement from a nearby civilian. However, peripheral vision (the physical ability to see in the periphery) and peripheral awareness (the ability to actually detect and act upon signals in the periphery) vary between individuals. Training methods to increase peripheral awareness could prove extremely beneficial to soldiers encountering just such a situation.

The Dynavision D2 (hereafter referred to as the D2) claims that it can do just that. It was originally designed to improve the visuomotor skills of athletes, but it has also been used extensively in rehabilitation of traumatic brain injury (TBI), stroke, and visual field deficit patients (Warren, 2008). Research has already shown that the D2 is a viable tool to measure whole-arm response time in young adults (Kuvadia, 2007). Specifically, the D2 claims to: increase visual search speed and efficiency, improve oculomotor skills such as localization, fixation, gaze shift, and tracking, increase peripheral visual awareness, visual attention and anticipation, and improve eye-hand coordination and visuomotor reaction time. To see significant improvement, participants must attend multiple training sessions. Participants are placed in front of a large board containing 64 lights in 5 rings (Figure 1) and must react as quickly as possible by hitting the lights as they turn on in random succession. Additionally, the board is integrated with a graphic display capable of flashing numbers, letters, and shapes at various speeds. Participants must call out whatever is displayed while still hitting the lights, significantly increasing the cognitive workload (Warren, 2008). The graphic display ensures that participants are using their peripheral vision to detect and hit the lights.

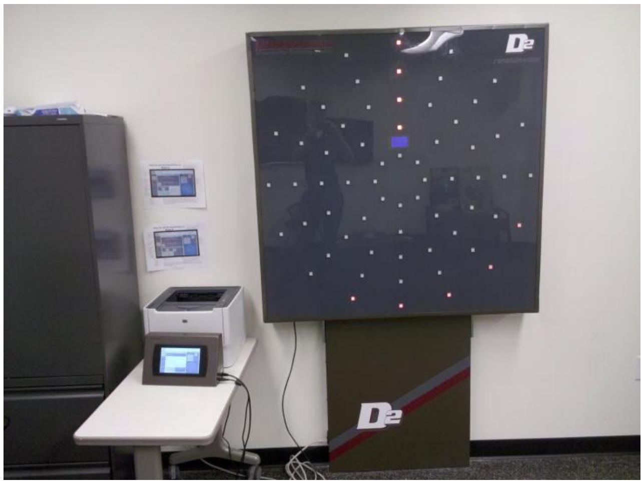

Figure 1. The Dynavision D2 by Performance Enterprises

Although a significant amount of research has been done on the performance benefits of the D2 in athletes and rehabilitation patients, a standard for comparison has not yet been established. Thus, we do not know what constitutes a poor, average, or good score, and therefore, cannot assess the effects of a neural impairment, prior athletic experience, or any number of other factors. The purpose of this research will be to develop a performance bell curve for young adults, age 17-23, prior to any significant amount of training on the D2 (some training is required to overcome the learning curve). This data will be used as a baseline for comparison for future rehabilitation patients, athletes, military personnel, and other users.

The perceptual task requires using both foveal and peripheral vision. While the fovea is directed at the graphic display as the user calls out the numbers, peripheral vision is used to detect and hit the lights. Attention is thus divided between the tasks, which increases cognitive workload and stress (Castiello & Umilta, 1988). According to research, processing peripheral vision information depends on three factors: the region stimulated, the task complexity, and the stimulus size (Edwards & Goolkasian, 1974). Yet in the same study, results showed that performance on simple light detection tasks in the periphery was nearly independent of the region stimulated. Participants performed almost equally well when the stimulus was presented in the "extreme periphery" as when presented in the "near periphery." This suggests that the participants' peripheral vision may be fixed, and that the D2 simply trains RT and visuomotor control. However, this experiment did not involve multiple sessions, so it is still plausible that a training effect exists. Additionally, experiments show that trained athletes perform better in peripheral awareness and eye-hand coordination tasks (Korins, 1933).

Adding a visual task, such as calling out the numbers on the display, further complicates peripheral detection. Research shows that attention to visual and auditory tasks during a peripheral vision test increases RT and decreases detections (Webster & Haslerud, 1964). Participants had to either count the number of flashes of a light or the number of clicks they heard while simultaneously attempting to detect lights in their peripheral vision. The decrease in performance was likely due to the divided attention caused by the visual and auditory tasks. Cognitive tasks, like counting, significantly reduce RT's in graphic aiming tasks where participants were required to draw a line from a start point to a target as quickly as possible (Van Gemmert & Van Galen, 1997). This is important because a participant's attention will be divided between calling out numbers and hitting lights, thus affecting RT.

The critical aspect involved in the D2 task is moving the arm and hand in order to hit each light, testing visuomotor control and RT. Peripheral vision has a significant role in detecting stimuli and monitoring movement in the environment. Experiments show that seeing one's movements somewhere in the visual field increases accuracy in pointing tasks (Abahnini & Proteau, 1999). However, accuracy is worse when the stimulus appears in the periphery and participants are not permitted to focus on the stimuli (Abrams, Meyer, & Kornblum, 1990; Bard, Hay, & Fleury, 1985). Since the D2 claims to improve eye-hand coordination and visuomotor control, performance measures such as accuracy and RT should improve as participants undergo more training on the system. Baseline comparisons will be particularly important in evaluating participants with neural impairments. It will then be possible to quantify the deficit associated with a specific impairment and subsequently determine if patients can be brought back to "normal." Further research could evaluate the exact performance benefits, such as resilience and target acquisition time, from training on the D2.

Methods

Participants

Participants were 18 USMA freshman cadets between the ages of 18 and 20 (average age 18.7 years). Sixteen were males and two were females. Sixteen were right hand dominant, with two left handed. All participants had 20/20 vision or correctable to 20/20. Nine wore glasses or contacts. All participants played sports, with 13 at the intramural level and 5 at the intercollegiate level. Participants were treated in accordance with the ethical standards established by the American Psychology Association. The research methods used in this experiment were approved by the U. S. Military Academy Human Subjects Use Committee.

Apparatus

For this experiment, participants trained on the Dynavision D2 lightboard, designed by Performance Enterprises in Ontario and manufactured by Artisan in Oklahoma. It consists of 64 lights arranged in a 5 circular rings with an LCD screen approximately four inches above the center of the four 4x4 foot board that can display numbers (reference Figure 1 for picture). The lights are actually buttons that afford the participant good tactile feedback when they hit the button to turn it off. Participants were exposed to one of four possible training modes while interacting with the board.

Procedure

Participants were tested in a within subjects design. The IV's were Session Number and Trial. The DV's were Average Reaction Time, Total Hits, Fastest/Slowest RT, and hits and reaction time in each ring and quadrant. At the initiation of the experiment participants were given a standardized briefing explaining all the procedures pertinent to their successful performance in the experiment. Following the brief they were asked to sign the informed consent form and ask any questions they may have. Participants were allowed to terminate their participation at any time during the experiment with no negative consequences and received 3% bonus credit toward their General Psychology grade. An initial demographic questionnaire was administered to determine the age, sex, height, weight, handedness, vision, and level of sport participation (intramural, club, or intercollegiate) of the participant. They were then verbally queried for basic medical history conditions that could interfere with their sensory reception to the visual stimulus. Upon completing this administrative portion of the experiment they began testing inside the lab room located in the Center for Enhanced Performance room of Jefferson

Hall (Library).

Once training began, participants were instructed to assume a comfortable athletic stance and stand at a distance from the board where they could easily reach all of the lights. They were then instructed to adjust the board height to where the LCD screen was located just below eye level. Participants were told to fixate their gaze on the LCD screen in the middle of the board and to keep their focus there for the entirety of the experiment.

The original training program consisted of six 20-30 minute training sessions occurring on Monday, Wednesday, and Thursday evenings for a 2-week period. Due to a some no-shows, our data analysis will consist of only the first four sessions. During each training session, the participant executed a set of four pre-programmed trials on the D2 one time, in that order. In Trial 1, the D2 was programmed for a 60-second run in which the lights would stay on until the participant hit them, at which point the next light would come on. Trial 2 was a 60-second run in which the participant would have 1 second to depress each light before the next light automatically came on. Trial 3 was a 60-second run in which the lights would stay on until they were depressed. Additionally, the LCD screen would flash four digits for 1 second at a time. A total of 10 sets of digits appeared per trial. Participants were instructed to read the digits aloud as they appeared on the LCD screen. Trial 4 was a 4-minute run in which the lights would stay on until they were depressed. Additionally, lights would only appear in the inner three rings. Participants were not permitted to view their results until after the final training session.

Up to three participants were run at a time during each session. Participants rotated between testing and resting periods within their group, giving them three 2-minute rest periods and an 8-minute rest period before Trial 4. Using the D2 can be both physically and cognitively taxing, so it is important to ensure the participant is fully prepared for each trial on the various modes. Upon completion of all six training sessions the participant answered a short questionnaire, then was debriefed and released with the opportunity to view their results for the first time.

Results

Table 1 below shows the descriptive statistics obtained from each trial. The Average Slowest RT for Trial 2 is skewed because participants had only 1 second to depress each light. If the participant missed a light, the time to hit the next light was reset. Thus, a participant could not have a reaction time slower than 1 second. Since Trial 4 (mode A-3) had a 4-minute run time—compared to only 60 seconds in the other trials—and that only the inner three rings displayed lights, we would expect to see a much higher number of hits, a faster Average RT and Average Fastest/Slowest RT. The data is consistent with this expectation. As such, we will analyze Trial 4 data separately from Trials 1-3.

Trial #	Avg Total Hits	Avg RT (s)	AVG Fastest RT (s)	Avg Slowest RT (s)
1	82	0.682	0.414	1.549
2	84	0.606	0.388	0.944
3	82	0.680	0.416	1.746
4	397	0.550	0.335	1.314

Table 1. Descriptive statistics for each trial, across all six sessions.

Minitab 15 software was used to perform the statistical analyses, by means of an ANOVA General Linear Model.

Analysis for Trials 1-3

Table 2 below shows the data analysis results for Trials 1-3. Significant results are highlighted in yellow.

	Total Hits	Avg RT	Fastest RT	Slowest RT
Age	F(1,214)=11.72, p=.001	F(1,214)=7.41, p=.007	F(1,214)=.24, p=.623	F(1,214)=3.21, p=.074
Height	F(1,214)=12.58, p<.001	F(1,214)=.07, p=.796	F(1,214)=.01, p=.929	F(1,214)=.29, p=.59
Weight	F(1,214)=21.13, p<.001	F(1,214)=.15, p=.703	F(1,214)=.24, p=.624	F(1,214)=.4, p=.53
Glasses/Contacts	F(1,214)=0, p=.984	F(1,214)=1.36, p=.244	F(1,214)=.01, p=.930	F(1,214)=4.1, p=.044
Sport Participation	F(3,214)=3.02, p=.031	F(3,214)=9.31, p<.001	F(3,214)=24.88, p<.001	F(3,214)=.39, p=.757
Session Number	F(3,214)=25.25, p<.001	F(3,214)=29.88, p<.001	F(3,214)=29.97, p<.001	F(3,214)=2.9, p=.036
Trial Number	F(2,214)=1.02, p=.361	F(2,214)=29.05, p<.001	F(2,214)=8.8, p<.001	F(2,214)=45.83, p<.001

	Ring 4 Hits	Ring 5 Hits	Ring 4 RT	Ring 5 RT
Age	F(1,214)=9.06, p=.003	F(1,214)=2.33, p=.129	F(1,214)=2.84, p=.093	F(1,214)=10.04, p=.002
Height	F(1,214)=5, p=.027	F(1,214)=1.85, p=.175	F(1,214)=.27, p=.606	F(1,214)=.44, p=.510
Weight	F(1,214)=6.14, p=.014	F(1,214)=6.72, p=.010	F(1,214)=1.25, p=.265	F(1,214)=1.34, p=.249
Glasses/Contacts	F(1,214)=.35, p=.556	F(1,214)=.53, p=.469	F(1,214)=1.07, p=.303	F(1,214)=1.6, p=.208
Sport Participation	F(3,214)=3.2, p=.025	F(3,214)=1.12, p=.343	F(3,214)=7.2, p<.001	F(3,214)=3.71, p=.013
Session Number	F(3,214)=10.46, p<.001	F(3,214)=13.32, p<.001	F(3,214)=23.67, p<.001	F(3,214)=18.07, p<.001
Trial Number	F(2,214)=19.31, p<.001	F(2,214)=7.03, p=.001	F(2,214)=23.69, p<.001	F(2,214)=37.74, p<.001

Table 2. Statistical results for Trials 1-3. Significant results are highlighted in yellow.

Of particular interest, since one of the goals was to assess the D2's use as a peripheral vision trainer, was performance in the outer two rings. Session Number was significant for Ring

4 Hits, Ring 5 Hits, Ring 4 RT, and Ring 5 RT. Additionally, the level of sport participation was significant for almost all of the responses. A Tukey comparison with a 5% family error rate suggests that "Corps Squad" (intercollegiate athletes in NCAA recognized sports) athletes have a faster average reaction time than intramural athletes, but were unexpectedly slower than "club" (intercollegiate athletes in non-NCAA recognized sports) athletes. However, only two corps squad athletes and three club athletes participated in the experiment.

Analysis for Trial 4

Table 3 below shows the data analysis results for Trial 4. Significant results are highlighted in yellow.

	Total Hits	Avg RT	Fastest RT
Age	F(1,70)=2.58, p=.113	F(1,70)=1.93, p=.181	F(1,70)=1.25, p=.269
Height	F(1,70)=6.74, p=.012	F(1,70)=.07, p=.798	F(1,70)=1.5, p=.225
Weight	F(1,70)=6.52, p=.013	F(1,70)=2.33, p=.132	F(1,70)=2.24, p=.139
Glasses/Contacts	F(1,70)=.02, p=.892	F(1,70)=2.13, p=.15	F(1,70)=.62, p=.436
Sport Participation	F(3,70)=3.99, p=.012	F(3,70)=10.57, p<.001	F(3,70)=16.34, p<.001
Session Number	F(3,70)=4.4, p=.007	F(3,70)=6.99, p<.001	F(3,70)=11.73, p<.001

	Slowest RT	Ring 3 Hits	Ring 3 RT
Age	F(1,70)=.207, p=.155	F(1,70)=1.87, p=.177	F(1,70)=3.49, p=.067
Height	F(1,70)=.51, p=.479	F(1,70)=7.36, p=.009	F(1,70)=.01, p=.915
Weight	F(1,70)=.31, p=.581	F(1,70)=7.16, p=.010	F(1,70)=1.25, p=.269
Glasses/Contacts	F(1,70)=1.39, p=.243	F(1,70)=0, p=.995	F(1,70)=2.87, p=.095
Sport Participation	F(3,70)=1.69, p=.179	F(3,70)=3.73, p=.016	F(3,70)=10.75, p<.001
Session Number	F(3,70)=42, p=.736	F(3,70)=4.05, p=.011	F(3,70)=6.16, p=.001

Table 3. Statistical results for Trial 4. Significant results are highlighted in yellow.

Once again, Sport Participation proved to be a consistently significant factor. Tukey comparison results for Trial 4 were identical to Trials 1-3, showing that the club athletes generally performed better than the corps squad athletes. Again, however, the *N* for these groups is too low to give reliable statistical results. In Trial 4, only the inner three rings lit up, so of most interest to us was the outermost ring. Session number was significant for both the Ring 3 Hits and the Ring 3 RT.

Establishing the Learning Curve

Although Session Number was found to be a significant factor in many of the response variables, we do not know how the data is changing throughout the sessions. The graphs in Figure 2 below show how participants performed over the course of the four sessions analyzed.

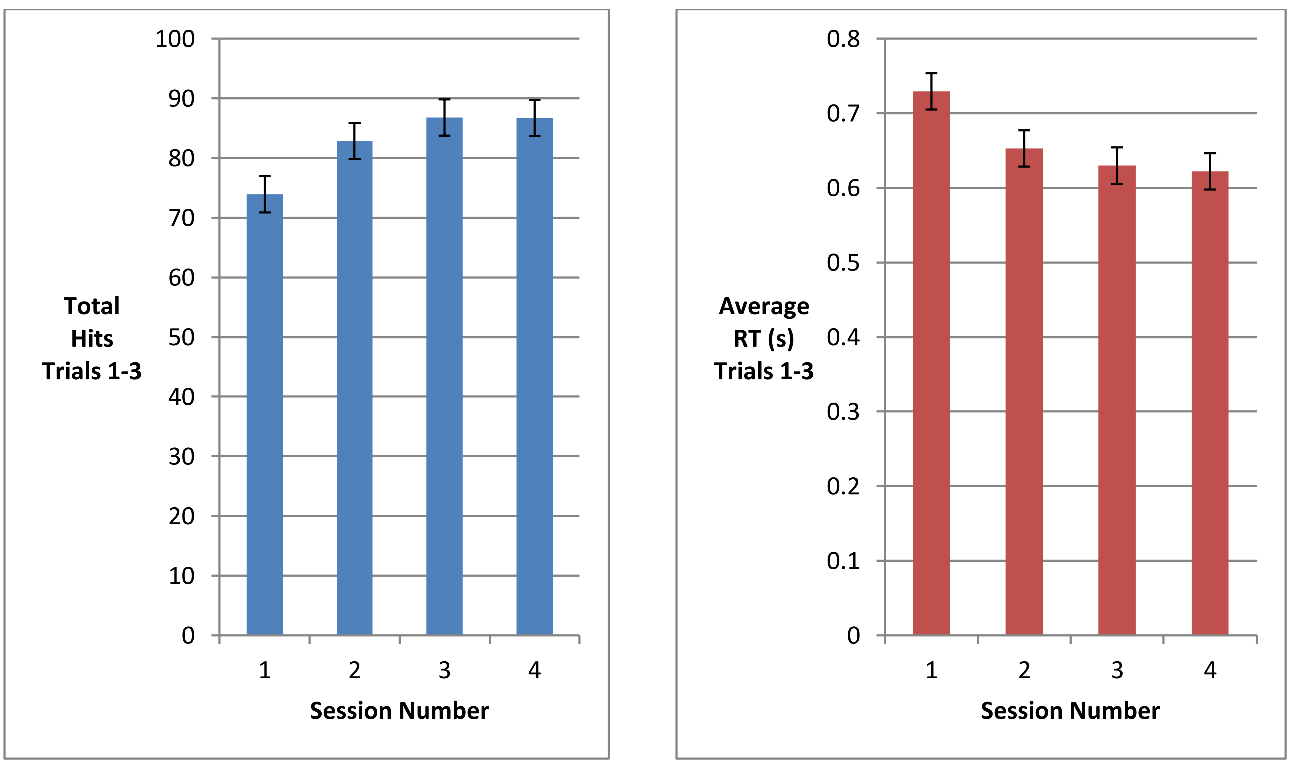

Figure 2. Graphs of Total Hits and Average Reaction Time for Trials 1-3, by Session Number

Figure 2 demonstrates the learning curve for the D2. As the number of sessions increase, the participants began to plateau between the third and fourth session. The fourth session appears almost identical to the third session for both Total Hits and Average RT. The data shows that after the fourth session, on average, participants demonstrate a RT that is .1 second faster than their first session. However, Figure 3 below shows that the number of Ring 5 Hits continues to increase through the fourth session.

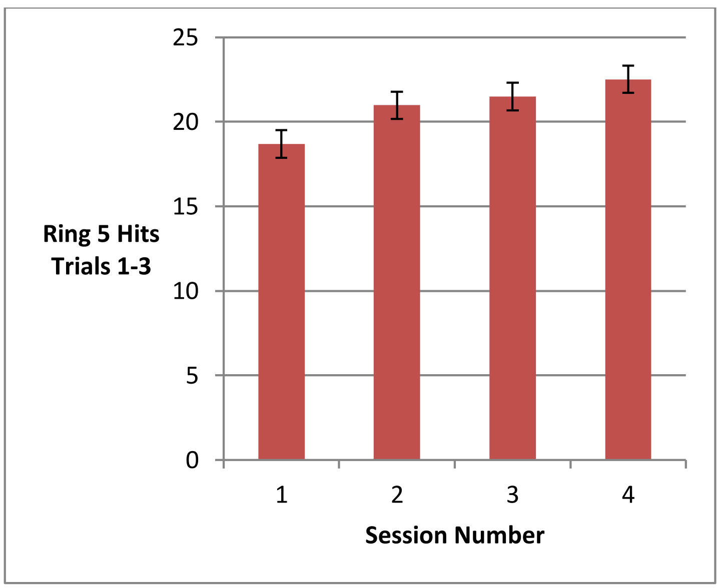

Figure 3. Graph showing steady increase in Ring 5 Hits throughout Sessions 1-4.

Baseline Data

Since participants seem to hit a performance ceiling at the fourth session, we used the data from Session 4 to create the baseline performance values. These values should be used to compare future D2 users' performance during training. Table 4 below shows the values we obtained from the Session 4 data. The data is correlated to the trial number so that users can determine how they should perform on each of the modes used in this experiment.

Trial Number	Total Hits	Avg RT (s)	Fastest RT (s)	Slowest RT (s)
1	87	0.639	0.381	1.391
2	87	0.584	0.365	0.939
3	86	0.643	0.392	1.449
4	413	0.524	0.308	1.308

Table 4. Baseline data for participants after four training sessions.

DISCUSSION

The results support our hypothesis that D2 users will reach an initial performance ceiling after only a few training sessions. Data shows that after just three training sessions using the training program in this experiment, users are “up to speed” on the D2. This result could be useful for developing training plans to help rehabilitate TBI patients and better train high performance athletes or soldiers. Additional training may result in a decrease in Slowest RT, suggesting that training may speed up cognitive processing. Future research could potentially look into varying the training program in order to either shorten the learning curve or prevent users from “topping out.”

Although the data suggests that peripheral vision is enhanced through training on the D2, since hits in rings 4 and 5 increase after each session, it may just be that the participants were getting better at the task itself, and that there was not a transfer of training to other areas. In order to determine if peripheral vision was actually improved, future research could use optometry equipment to test peripheral visions before and after training on the D2. Also, to see if there is a transfer of training from the D2 into sports, future research could assess sports performance before and after training. However, this experiment would have to be tightly controlled, as a number of factors can also affect sports performance, such as diet, attitude, workout program, etc

From a military standpoint, it would be interesting to see if there was a transfer of training over to marksmanship ability or soldier detection tasks, such as spotting a camouflaged person.

We also established baseline data to be used as a standard of comparison for athletes, rehabilitation patients, military personnel, and others. However, this data must be used with caution. All the participants in this study were USMA cadets, and so may not be a representative sample. High performance standards are necessary to gain admission, and cadets are generally highly intelligent, motivated, and in good physical condition. Other populations may require more sessions before peaking, and their peak values may not be as high.

Overall, this experiment succeeded in its goals. We verified that the D2 may be a viable option for training peripheral vision, established a learning curve for training, and determined baseline performance levels to use as benchmark values for D2 users. As the body of research on the D2 is limited, there are numerous opportunities for future studies on the D2 and other similar systems.

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