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ORIGINAL ARTICLE

An analysis of the impact of pressure on performance among professional darts players

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ABSTRACT

The aim of the study was to examine whether and to what extent increased levels of pressure affect the performance quality of the world's top darts players. This investigation contributes to the understanding of the psychological factors that influence performance in professional darts and in professional sports overall. Data was collected from over sixty professional tournaments held over a period of two years. The players were divided into 5 groups based on the quality of their performance during the studied period. The point values were divided into 7 groups, where the criterion was the difficulty of finishing the leg at a given score. The level of pressure was primarily determined by the opponent's score situation in a given moment. Data analysis using statistical methods such as tests of proportions and the Cochran-Armitage test did not indicate any statistically significant impacts of pressure on performance among professional players – neither positive nor negative. The results indicate a high level of mental resilience among professional darts players.

Keywords: Sports psychology, Mental resilience, Test of proportion, Cochran-Armitage test.

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INTRODUCTION

Darts belongs to a group of sports where the role of the mental factor is frequently discussed. To be more precise, when discussing the mental aspect in this context, it generally refers to a specific set of psychological traits. Possessing or lacking these traits has a positive or negative effect on a player's performance. However, the emphasis on psychology in darts is less surprising when we consider the opinions of the most prominent experts in the field: the players themselves. For example, Dr. Linda Duffy, a two-time British Open champion, argues that at a certain level of the sport, all players become experts at hitting any target on the board. Therefore, the factor that determines the final hierarchy is the mental aspect. She highlights higher levels of mental toughness, concentration, and the ability to stay composed separate the "*winners*" from the rest ('The psychology of darts' with Dr Linda Duffy, 2017). Raymond Smith, a participant in the Last 16 of the World Championship and one of Australia's top players, makes a similar point. He believes that the subconscious is responsible for calculations such as the strength of the throw or correct hand placement, while the conscious mind introduces unnecessary elements into the equation, leading to overthinking, stress, or even panic (Smith, 2019). In contrast, Robert Thornton, the World Grand Prix and UK Open champion, describes high self-confidence as the main characteristic of the best players (Strength and weakness - Darts interview with Robert Thornton). Mensur Suljović, the Champions League winner, claims that 60% of skills can be developed through training, while the remaining 40% rely on the player's psyche (Mensur Suljović: Players think training mentally for games is weak – it's not, 2018). Taking an even stronger stance, Peter Wright, the two-time world champion, firmly asserts that mentality accounts for 90% of a player's success (Peter Wright: I'd be as good as Taylor if I hadn't quit darts, 2018). The above opinions also seem to be supported by an occasional psychological affliction among darters known within the community as "*dartitis*". Dr. Linda Duffy defines dartitis as a psychological disorder that hinders the execution of the movement required to throw a dart, without any prior physical injury. Athletes experiencing this condition often describe it as a fear of failure. It is worth noting that similar phenomena, known as the "*yips*", can also affect individuals in sports such as golf or snooker (Clarke et al., 2015).

The role of psychology in darts can also be explored from an objective perspective, based on research conducted on the subject. However, it is important to note that these studies are usually conducted on beginners who have limited prior experience with the sport. While the findings from such experiments may not directly translate to the professional level, they can still offer valuable insights and serve as an interesting point of reference. Some studies examine the impact of employing mental imagery and self-talk on performance levels in darts. These studies measure performance using both objective metrics, such as accuracy of throws, and subjective evaluations of one's own play. These analyses generally demonstrate a positive effect of positive imagery and self-talk on objective performance (Cumming et al., 2006). However, there is no consensus regarding the subjective assessment of performance. While some experiments indicate a positive effect in this area (Afsanepurak et al., 2012), the findings are not universally consistent. On the other hand, concerning the objective measurement of performance level, it is worth noting that negative mental imagery and negative self-talk can have the opposite effect, potentially hindering performance (Van Raalte et al., 1995). Also, another variation of internal dialogue known as "*instructional self-talk*" has been explored, particularly in research involving younger players. Findings indicate that instructing oneself on the proper technique and approach to throwing can lead to noticeably faster progression (Aghdasi & Touba, 2012). Furthermore, certain studies aim to determine the influence of psychological training on the overall quality of the game. They indicate that mental training, which includes various components such as relaxation techniques, goal-setting, emotional control exercises, concentration improvement, as well as enhancing self-esteem and self-confidence, can compensate for potential deficiencies from fewer physical training sessions (Straub, 1989). Beneficial effects have also been noted

from the MAC (mindfulness-acceptance-commitment) approach, which, rather than attempting to control, replace or eliminate negative emotions and feelings, emphasizes full awareness and non-judgmental acceptance of these emotions, ultimately leading to the development of the ability to overcome obstacles (Zhang et al., 2016). Additionally, traits such as anxiety management and anger control have also been identified as crucial for darts players (Low, 1994). Research also indicates the positive impact of "*external focus*" for players, whereby directing attention to a specific point on the dartboard, rather than focusing on one's own body movements, has been shown to yield better results (Lohse et al., 2010).

Having recognized the significant role of the mental aspect in the realm of darts, the question naturally arises: how mentally strong are the best players? Answering such a question is as complex as defining what constitutes a "*mentally strong person*". However, in the context of darts games, particularly the 501 double-out formats analysed in this study, two specific characteristics allow for a more focused investigation:

- Over the course of numerous games, it becomes possible to identify regularly recurring events,
- All players' actions can ultimately be measured by the number of points they score.

The first characteristic provides ample data to be collected and formulated into a research problem, while the second characteristic allows for an investigation of that problem. These aspects converge on the core issue and central topic of this study: Do professional darts players exhibit decreased (or increased) performance under heightened pressure from their opponents?

In the world of darts, the word "*pressure*" most often appears in the context of the following situation:

- Player A is set on a low finish, e.g. 32 points,
- Player B, who is currently throwing, does not have the opportunity to finish the leg (for example, he has 196 points left on the counter).

In such a situation, sports commentators often remark that the only thing Player B can do is to hit a high-value score (preferably 180, which would leave 16 points) to put pressure on the opponent. Assuming Player B performs flawlessly, the question then arises regarding how Player A will react to this situation. There are three possible options for Player A's response:

1) Player A may feel the additional pressure of having to hit the required score, which could potentially decrease their chances of a successful checkout and result in a loss of the leg.
2) The need to hit the required score may increase Player A's concentration level, thereby increasing their chances of a successful checkout.
3) The opponent's score may have no effect on Player A's performance.

While the first answer probably appears to be the most intuitive and the most widespread among fans and experts, it is crucial to examine the general tendency among players in similar situations to uncover the truth. Does the additional pressure from the opponent truly lead to a decrease in the effectiveness of finishing the leg, or does it have the opposite effect? The aim is to answer the question of how susceptible the world's best players are to stressful situations.

The study to be presented will be divided into two main parts. The first part will involve the compilation of preliminary statistics, while the second part will focus on finding an answer to the main question at hand.

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METHODOLOGY

The study presented here is based on a comprehensive statistical analysis of over 710,000 situations, meticulously collected from nearly 7,600 darts games in the 501 double-out game formats played during the PDC Players Championship in the years 2021 – 2022. Among these situations, approximately 185,000 of them allowed players to attempt to close out a leg, representing a significant sample size for analysis. Each individual situation in this study refers to a single turn at the board made by a player, involving a maximum of three dart throws. It is important to note that the data collected was not manipulated or orchestrated for the purposes of the study; it naturally occurred during the course of the games. The information for each turn was recorded using Python and Visual Basic for Applications (VBA) scripts to minimize any potential data completion errors. The entire dataset, available in .xlsx format, is available to download via Dropbox (PDC Players Championship 2021 – 2022 database, 2023).

All the data was sourced from the DartConnect service, a scoring application that provides detailed information on the progression of all games played during the series. As the majority of Players Championship games are not broadcasted by the PDC via pdc.tv, DartConnect is the primary and most comprehensive source of information on how all games are played. It offers real-time match information in text format, which seems to be sufficient for conducting the necessary analyses in this study. Figure 1. presents an excerpt from the recording of a sample leg, representing a single part of a game.

Game 1.1 - 501 SIDO **32 - 0** 01:47

!	Player	Turn	Score	Rnd	Score	Turn	Player	!
100	Rusty-Jake Rodriguez	100	401	1	401	100	John Michael	100
140	Rusty-Jake Rodriguez	140	261	2	301	100	John Michael	100
140	Rusty-Jake Rodriguez	140	121	3	161	140	John Michael	140
	Rusty-Jake Rodriguez	57	64	4	71	90	John Michael	
	Rusty-Jake Rodriguez	32	32	5	0	71	John Michael	DO
93.80			3 Dart Avg			Darts: 15		100.20

Source: https://recap.dartconnect.com/games/61fe772d5c196703f8a22f91

Figure 1. Excerpt from a record of a darts game (DartConnect system).

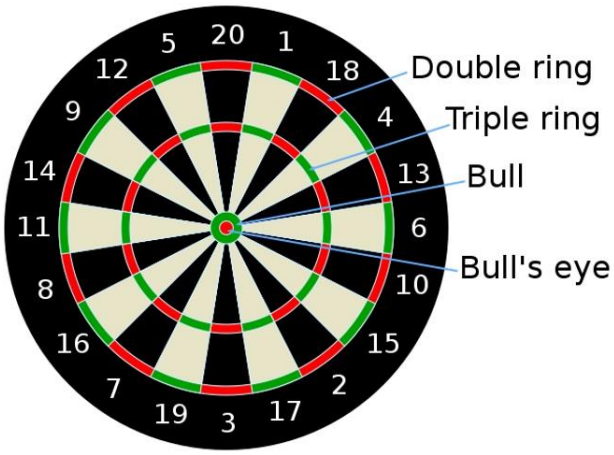
The excerpt contains a lot of useful data, including:

- The number of points on both counters before every turn at the board,
- The number of points scored in three darts in every turn in the leg,
- The number of darts needed to finish the leg.

Darts rules

Given that darts remains relatively niche on a global scale, let's briefly outline the rules of the game for the 501 double-out formats, which will be the focus of the study. In this format, commonly used in tournaments organized by the PDC, the objective for each player is to reduce their score from 501 points to 0. During each turn at the dartboard, players have three darts at their disposal. The number of points they score with each dart is subtracted from their current score. For instance, if a player scores 140 points in their first attempt, their counter will be reduced to 361 points. Subsequent throws are deducted accordingly. A leg, which denotes a single game within a match, commences with both players having 501 points each. The leg

continues until one player reaches 0 points and wins it. Figure 2. can be referred for a visual representation of the standard dartboard used in the game.



Source: https://commons.wikimedia.org/wiki/File:Dartboard.svg

Figure 2. Standard dartboard.

Scoring on the dartboard is determined by the following rules:

- The red centre of the board (bull's eye) awards the player 50 points,
- The green centre of the board (bull) awards the player 25 points,
- The narrow inner circle (triple ring) triples the value of the corresponding segment. For example, hitting a triple 18 would yield 54 points,
- The wider outer ring (double ring) doubles the value of the corresponding segment. For example, hitting a double 20 would result in 40 points,
- The large black or white fields grant the player the points assigned to the outer sections of the board.

Each leg must conclude with a double value or a hit on the red centre (a successful attempt is called "*checkout*"). For instance, if a player has 32 points remaining, they must hit a double 16 to finish the leg (hence the term "*double-out*" in this format of the game).

In the Players Championship tour, which served as the data source for this study, games are played until one player wins 6, 7 or 8 legs (depending on the tournament phase).

Introductory statistics

The main part of the analysis will involve the creation of introductory statistics, which are essential for ensuring the readability of the findings. Introductory statistics will be divided into two parts:

1) A summary of the groups of point values based on the probability of checkout, distinguishing between the easiest and most difficult values to finish.
2) A ranking of players participating in the Players Championship tour, evaluating their efficiency in closing out legs and the scoring efficiency of their first 9 darts in each leg.

The probability of checkout at different score values

In this study (and exclusively for the purposes of this study), the probability of checkout from a specific value will be defined as the percentage of situations where players participating in the Players Championship tour

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successfully closed a leg with that particular number of points remaining. For example, if there were a total of 1,000 instances in the competition (years 2021 – 2022) where a player had 64 points left, and out of those, 450 legs were closed, the probability of the checkout with 64 points would be calculated as 45%. The determination of probability in this study does not take into account which player was approaching the board; instead, it focuses on the average success rate. Additionally, the determination of probability does not consider whether a player actually attempted to close the leg at a given time. For example, situations may arise where one player has a high value to finish, such as 170, while the other player has no chance of finishing if they return to the board. In such cases, the first player may choose to set up their score on a comfortable double rather than forcefully attempting to finish the game. Due to the lack of available video footage of the games (as only a small proportion of Players Championship series games are broadcasted), it is not possible to determine the players' intentions in individual situations, and therefore this factor will be ignored. Consequently, the determined probabilities may slightly underestimate some of actual values, especially the highest ones. However, these differences should not significantly impact the results of the study, as the determined probabilities primarily serve to just categorize the various possibilities of ending a leg into groups ranging from easiest to most difficult.

Table 1. Checkout probabilities for all possible values (based on success rate).

Value	Success rate	Attempts	Value	Success rate	Attempts	Value	Success rate	Attempts
27	80.95%	21	**8**	77.64%	2080	**32**	77.50%	6921
24	76.29%	2269	**16**	75.91%	4841	**40**	75.87%	11771
28	74.18%	705	**12**	73.81%	1115	**20**	73.38%	6160
36	73.27%	3393	**4**	72.04%	1080	**26**	70.63%	143
21	70.37%	27	**22**	68.50%	200	**14**	68.23%	384
18	67.28%	1134	**51**	65.33%	323	**34**	64.93%	134
53	64.77%	193	**46**	64.73%	638	**49**	64.71%	238
30	64.46%	287	**48**	64.38%	1415	**42**	64.06%	473
35	63.77%	207	**25**	63.52%	3013	**44**	63.44%	651
50	63.43%	990	**13**	62.96%	81	**41**	62.90%	1105
54	62.88%	590	**10**	62.84%	1741	**38**	62.52%	643
6	62.01%	458	**52**	62.00%	1513	**47**	61.96%	552
11	61.43%	140	**45**	61.10%	365	**31**	60.14%	138
58	59.13%	739	**56**	58.69%	2089	**9**	58.47%	248
29	58.33%	12	**60**	57.28%	2336	**39**	57.24%	145
23	57.14%	14	**43**	56.72%	238	**57**	56.49%	439
59	56.33%	245	**7**	56.31%	103	**5**	55.62%	543
33	55.14%	107	**15**	55.08%	118	**2**	54.72%	424
55	53.31%	272	**19**	52.38%	84	**37**	52.00%	50
67	49.31%	436	**64**	48.80%	1752	**66**	47.75%	890
65	47.62%	861	**62**	47.25%	965	**61**	46.06%	584
68	45.98%	1816	**75**	45.67%	473	**3**	44.93%	69
70	44.81%	1571	**71**	44.40%	545	**72**	44.19%	1851
73	43.63%	259	**74**	43.26%	1149	**69**	42.58%	209
76	42.41%	2153	**63**	41.74%	218	**78**	41.63%	1165
17	41.18%	51	**82**	39.95%	1159	**80**	39.84%	2430
77	38.89%	360	**88**	37.38%	1022	**87**	36.91%	1035
93	35.70%	381	**84**	35.40%	1435	**81**	35.37%	2587
85	35.00%	860	**89**	34.62%	439	**79**	34.62%	286
86	33.98%	1289	**83**	33.68%	582	**90**	33.46%	1315
96	32.03%	1848	**94**	31.84%	716	**92**	30.83%	827
91	29.60%	625	**100**	29.04%	2190	**97**	28.77%	577
95	27.29%	590	**103**	25.16%	465	**98**	24.58%	655
109	23.01%	478	**105**	22.76%	681	**113**	22.22%	378
101	22.15%	1133	**99**	21.90%	274	**110**	21.39%	1566

108	21.17%	1181	**111**	21.13%	478	**104**	20.92%	1463
102	20.70%	773	**106**	20.59%	1146	**107**	20.55%	730
112	20.31%	1172	**116**	20.29%	1735	**117**	19.21%	505
118	19.07%	713	**115**	19.00%	442	**120**	17.67%	2162
114	16.30%	681	**119**	15.23%	302	**122**	13.07%	918
126	12.50%	1240	**127**	12.33%	1144	**124**	11.97%	2030
121	11.56%	4066	**123**	11.21%	562	**130**	10.75%	2055
128	9.53%	986	**125**	8.13%	836	**135**	7.89%	672
132	6.82%	1378	**134**	6.71%	834	**129**	6.69%	703
149	6.40%	422	**138**	6.33%	1058	**144**	6.23%	1461
143	6.21%	773	**157**	6.09%	558	**142**	6.06%	1287
140	6.02%	2177	**151**	5.92%	507	**156**	5.91%	1235
133	5.90%	373	**131**	5.68%	651	**136**	5.68%	1742
148	5.43%	976	**145**	5.33%	1051	**160**	5.31%	2184
146	5.18%	1275	**150**	5.09%	1278	**152**	5.01%	779
137	4.99%	541	**141**	4.98%	2149	**147**	4.87%	678
154	4.54%	573	**153**	3.99%	351	**139**	3.78%	502
158	3.70%	676	**170**	3.20%	5813	**155**	3.16%	475
164	2.22%	3745	**167**	2.13%	2720	**161**	2.10%	4519

Source: original work based on: https://tv.dartconnect.com/events/pdc

After obtaining a comprehensive summary of the values and their corresponding probabilities, they were categorized into distinct groups based on the frequency of checkouts (Table 2.)

Table 2. Values grouped by checkout probability.

Checkout probability						
> 70%	50 - 70%	40 - 50 %	25 - 40%	10 - 25%	3 - 10%	0 - 3%
4, 8, 12, 16, 20, 24, 28, 32, 36, 40	2, 5, 6, 7, 9, 10, 11, 13, 14, 15, 17, 18, 19, 21, 22, 23, 25, 26, 27, 29, 30, 31, 33, 34, 35, 37, 38, 39, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60	3, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 80	79, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 100	99, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 126, 127, 130	125, 128, 129, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 160	170, 164, 167, 161

Source: original work based on: https://tv.dartconnect.com/events/pdc

In compiling the above summary, several adjustments were made:

- Values 17 and 27 were assigned to the 50 – 70% group due to the low number of samples,
- Values 80 and 77 were assigned to the 40 – 50% group due to probability oscillating at the border of the interval and similarity to values already present in this group,
- Value 98 was allocated to the 25 – 40% group, also due to probability oscillating at the border of the interval and similarity to values already present in this group,
- Value 155 was assigned to the 3 – 10% group due to similarity to values already present in this group.

Similarly, value 170 was assigned to the 0 – 3% group.

This resulted in 7 groups of values with the following characteristics:

- Group I: > 70%: all the easiest opportunities to close a leg, allowing the turn to be completed with only one dart. Even if there is a mistake inside the board (e.g., hitting S16 at a value of 32), there is no need to split the value to access a double,

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- Group II: 50 – 70%: uncharacteristically left doubles (e.g. 26, 38 etc.) and values which also require one single to be thrown first to close a leg (e.g. 52, 60),
- Group III: 40 – 50%: values which require either two singles or a triple hit in the first dart to finish without the need for a bull's eye. For example, 67 can be closed by hitting T17-D8 or S17-S18-D16,
- Group IV: 25 – 40%: values which, if a treble is missed, will require an attempt to finish the leg on a bull's eye (e.g., 88 = S20 + S18 + 50). All the values in this group can be closed in two darts if the first dart falls into a triple value (e.g., 92 = T20 + D16). Also, the tricky 79 finish is included,
- Group V: 10 – 25%: these values cannot be finished in two darts (or are rarely done so) and generally require hitting at least one treble. For example, 120 = T20 + S20 + D20,
- Group VI: 3 – 10%: this group consists of all other values (except those in group VII) that require two trebles to finish (e.g., 148 = T20 + T20 + D14) or the use of the centre of the board at some point (e.g., 129 = S19 + T20 + 50),
- Group VII: 0 – 3%: all the most complicated values to finish, requiring hitting two trebles and a bull's eye.

By making the above corrections, the groups become more homogeneous – each group contains a set of values that are similar to each other in terms of their characteristics.

Ranking of players

A second useful action would be to divide players into groups based on their skill level, similar to the division of values. Although it may seem that the simplest way would be to rank players based on their achievements over the studied period, such an approach would have one major problem – the studied period covers two years, while some players only participated in the circuit for one year or played irregularly (due to an increasingly busy tournament schedule, it happens that top players intentionally skip certain tournaments). In this case, the better way will be to assess a player's skill by evaluating their performance in two phases that occur in each leg:

- The scoring phase, which occurs at the beginning and middle of the leg, where the player's objective is to accumulate as many points as possible,
- The closing phase, which takes place at the end of the leg, where the player's goal is to execute a finishing combination.

In darts statistics, the efficiency in the scoring phase is commonly measured by the average of the first 9 darts thrown in a leg. This measure is used because it's extremely uncommon for a leg to be finished within 9 throws. Hence, the player's "*scoring power*" is defined as the average of the first 9 darts thrown in legs over a two-year period of play.

On the other hand, the efficiency of a player in the closing phase will be determined by their finishing efficiency in three groups of values: > 50%, 25 – 50%, 3 – 25%. These groups were formed by combining the previous groups. However, the highest values, specifically 170, 167, 164 and 161, are excluded from the analysis. This is due to the variation in players' preferences when faced with such values. Some players prefer to set themselves up for a comfortable double, even if the opponent has the possibility to finish on their next turn (which is unlikely to happen).

Table 3. provides a summary of the highest scoring players, including only those who had a minimum of 300 attempts to close a leg.

Table 3. Players Championship 2021 – 2022: Ranking of players based on first 9 darts average.

Rank	Player	First 9	Rank	Player	First 9	Rank	Player	First 9
1	Gerwyn Price	108.08	**2**	Michael van Gerwen	107.86	**3**	Josh Rock	107.32
4	Jonny Clayton	107.31	**5**	José de Sousa	107.30	**6**	Damon Heta	107.20
7	Dirk van Duijvenbode	107.15	**8**	Gary Anderson	106.98	**9**	Peter Wright	106.65
10	Dave Chisnall	106.28	**11**	Michael Smith	105.94	**12**	Krzysztof Ratajski	105.70
13	Rob Cross	105.68	**13**	Luke Humphries	105.68	**15**	Chris Dobey	105.52
16	Dimitri Van den Bergh	105.14	**17**	Nathan Aspinall	104.90	**18**	Callan Rydz	104.84
19	Ryan Searle	104.70	**20**	Joe Cullen	104.66	**21**	Danny Noppert	104.62
22	Stephen Bunting	104.59	**23**	Adrian Lewis	104.50	**24**	Martin Schindler	104.48
25	Ross Smith	104.40	**26**	Ian White	103.07	**27**	Daryl Gurney	102.69
28	Mensur Suljovic	102.39	**29**	Brendan Dolan	102.10	**30**	Steve Lennon	102.00
31	Jim Williams	101.99	**32**	Gian van Veen	101.96	**33**	Raymond van Barneveld	101.61
34	Gabriel Clemens	101.37	**35**	Simon Whitlock	101.27	**36**	Alan Soutar	101.23
37	Kim Huybrechts	101.22	**38**	Cameron Menzies	101.19	**39**	Scott Williams	101.13
40	James Wade	101.13	**41**	Andrew Gilding	100.98	**42**	Mervyn King	100.89
43	Mike De Decker	100.80	**44**	Boris Krcmar	100.71	**45**	Florian Hempel	100.56
46	Jermaine Wattimena	100.49	**46**	Scott Mitchell	100.49	**48**	Jamie Hughes	100.39
49	Kevin Doets	100.19	**50**	Matt Campbell	100.17	**51**	Jason Lowe	100.17
52	Rusty-Jake Rodriguez	100.16	**53**	Mario Vandenbogaerde	100.11	**54**	Ryan Joyce	100.05
55	James Wilson	100.02	**56**	Maik Kuivenhoven	99.98	**57**	William O'Connor	99.93
58	Keane Barry	99.89	**59**	Geert Nentjes	99.81	**59**	Luke Woodhouse	99.81
61	Vincent van der Voort	99.73	**62**	Ron Meulenkamp	99.54	**63**	Jeffrey De Zwaan	99.45
64	Rowby-John Rodriguez	99.44	**65**	Mickey Mansell	99.40	**66**	Ritchie Edhouse	99.33
67	Karel Sedlacek	99.32	**68**	Steve Beaton	99.29	**69**	Madars Razma	99.19
70	Lee Evans	99.15	**71**	Niels Zonneveld	99.14	**72**	Andy Boulton	99.10
73	Jamie Clark	99.00	**74**	Richie Burnett	98.98	**75**	Ricky Evans	98.97
75	Scott Waites	98.87	**77**	Keegan Brown	98.84	**78**	Darius Labanauskas	98.81
79	Lewy Williams	98.76	**80**	Robert Thornton	98.71	**81**	Justin Pipe	98.56
82	John Henderson	98.49	**83**	Alan Tabern	98.47	**84**	Ricardo Pietreczko	98.43
85	Ryan Meikle	98.41	**86**	Chas Barstow	98.38	**87**	Martijn Kleermaker	98.32
88	Ryan Murray	98.29	**89**	John O'Shea	98.19	**90**	Krzysztof Kciuk	98.18
91	Tony Martinez	98.09	**92**	Kai Fan Leung	98.07	**92**	Joe Murnan	98.07
94	Ted Evetts	98.06	**95**	Connor Scutt	97.91	**95**	Martin Lukeman	97.91
97	Nathan Rafferty	97.83	**98**	Stephen Burton	97.78	**99**	Jason Heaver	97.68
100	Jelle Klaasen	97.55	**101**	Peter Jacques	97.48	**102**	George Killington	97.41
103	Jesus Noguera	97.39	**104**	Devon Petersen	97.30	**105**	Jeff Smith	97.14
106	Max Hopp	96.78	**107**	Jim McEwan	96.74	**108**	Danny Baggish	96.48
109	Radek Szagański	96.47	**110**	Steve West	96.42	**111**	Gordon Mathers	96.38
112	Geert De Vos	96.35	**113**	Danny Jansen	96.21	**114**	Darren Webster	96.10
115	José Justicia	96.04	**116**	Eddie Lovely	95.90	**117**	Adam Gawlas	95.81
118	Shaun Wilkinson	95.76	**119**	Jules van Dongen	95.65	**120**	Berry van Peer	95.56
121	Pete Burgoyne	95.53	**122**	Martin Atkins	95.37	**123**	Matthew Edgar	95.28
124	Danny van Trijp	95.15	**125**	Martin Thomas	95.02	**126**	Brian Raman	94.84
127	Zoran Lerchbacher	94.82	**128**	William Borland	94.73	**129**	Gary Blades	94.72
130	Bradley Brooks	94.43	**131**	Adam Hunt	94.39	**132**	Luc Peters	94.27
133	Brett Claydon	94.21	**134**	Nick Kenny	94.18	**135**	Ross Montgomery	94.16
136	Jack Main	94.08	**137**	Steve Brown	94.03	**138**	Kevin Burness	94.00
139	Josh Payne	93.97	**140**	Damian Mol	93.81	**141**	Boris Koltsov	93.77
142	Wayne Jones	93.64	**143**	Jon Worsley	93.52	**144**	David Evans	93.48
145	Michael Rasztovits	93.13	**146**	Nick Fullwell	93.00	**147**	John Michael	92.56
148	Andy Hamilton	92.50	**149**	Jimmy Hendriks	91.87	**150**	Derk Telnekes	91.66
151	Ciaran Teehan	91.61	**152**	Peter Hudson	91.57	**153**	Lisa Ashton	91.32
154	Aaron Beeney	91.01	**155**	Jake Jones	90.52	**156**	John Brown	88.94
157	Glen Durrant	87.66						

Source: original work based on: https://tv.dartconnect.com/events/pdc

The second ranking, which assesses the efficiency of finishing, involves three sub-rankings based on different value groups. These sub-rankings are as follows:

- Ranking of checkout efficiency for values in the first and second groups (> 50%),

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- Ranking of checkout efficiency for values in the third and fourth groups (25 – 50%),
- Ranking of checkout efficiency for values in the fifth and sixth groups (3 – 25%).

Due to the extensive amount of data, the complete rankings cannot be included in this paper. However, a comprehensive file containing all the collected statistics, including the full rankings, is also available for download via Dropbox. To provide a glimpse of the results, Tables 4., 5. and 6. present the Top 10 players in each of the aforementioned groups of values.

Table 4. Players Championship 2021 – 2022: Top 10 players with highest checkout efficiency (values from groups I and II).

Rank	Player	Efficiency (I. II)	Attempts
1	Michael van Gerwen	78.39%	620
2	Brendan Dolan	77.65%	707
3	Damon Heta	77.38%	924
4	James Wade	76.94%	633
5	Ryan Joyce	76.02%	563
6	Peter Wright	75.80%	785
7	Brian Raman	75.53%	188
8	Lee Evans	75.52%	143
9	Andy Boulton	75.34%	446
10	Michael Smith	75.08%	935

Source: original work based on: https://tv.dartconnect.com/events/pdc

Table 5. Players Championship 2021 – 2022: Top 10 players with highest checkout efficiency (values from groups III and IV).

Rank	Player	Efficiency (III. IV)	Attempts
1	Cameron Menzies	50.76%	132
2	Matt Campbell	48.13%	160
3	Brendan Dolan	47.82%	458
4	James Wade	47.59%	374
5	Danny Noppert	46.59%	455
6	José de Sousa	46.29%	499
7	Ryan Meikle	46.28%	309
8	Jonny Clayton	46.07%	484
9	Karel Sedlacek	45.95%	222
10	Ritchie Edhouse	45.89%	316

Source: original work based on: https://tv.dartconnect.com/events/pdc

Table 6. Players Championship 2021 – 2022: Top 10 players with highest checkout efficiency (values from groups V and VI)

Rank	Player	Efficiency (V. VI)	Attempts
1	Matt Campbell	16.67%	258
2	Peter Wright	16.46%	723
3	Gerwyn Price	16.29%	528
4	Damon Heta	15.77%	799
5	Jonny Clayton	15.66%	613
6	Rob Cross	15.63%	768
7	Joe Cullen	15.44%	609
8	Michael van Gerwen	15.38%	520
9	Scott Waites	15.00%	380
10	Josh Rock	14.83%	290

Source: original work based on: https://tv.dartconnect.com/events/pdc

From the sub-tables provided above, it is possible to calculate the average ranking position for each player in the three aforementioned rankings. By considering these average positions, the final ranking of efficiency in finishing can be determined.

This method of ranking players is more relevant compared to evaluating overall checkout efficiency without considering different groups of values. The latter approach may favour high-scoring players who frequently encounter lower-value finishes, thereby inflating their overall efficiency. This aspect is often overlooked, despite its relevance when comparing two different players. For instance, among the top three highest-scoring players, the percentage of attempts to close values from group I accounted for 24.7%, 24.7% and 22.1% of their total attempts, respectively. In contrast, among the three lowest-scoring players, it accounted for 16.4%, 17.7% and 17.4%. Thus, weaker scorers are further disadvantaged in terms of their checkout efficiency, as they are less likely to encounter the simplest finishing scenarios.

The method presented here, while more accurate, may still be subject to potential limitations due to the possibility of insufficient data, despite analysing almost 170,000 attempts to close a leg. When examining the rankings, there are instances where individual players have achieved high positions with a noticeably lower number of attempts compared to other players in the top positions. This observation might raise concerns. However, it is important to consider that the final finishing efficiency ranking is composed of three sub-rankings, which to some extent mitigates the impact of individual positions that may not fully reflect the reality. It is also worth noting that the primary purpose of creating an overall ranking is to estimate the skill level of individual players in order to categorize them into different groups, rather than providing an exact analysis. To achieve a more precise evaluation, as previously mentioned, a larger dataset would be required. The full ranking of checkout efficiency is presented in Table 7.

Table 7. Players Championship 2021 – 2022: Overall rankings of players based on checkout efficiency.

Rank	Player	Avg rank	Rank	Player	Avg rank	Rank	Player	Avg rank
1	Damon Heta	7.33	**2**	Brendan Dolan	8.33	**3**	Jonny Clayton	9.00
4	Peter Wright	10.33	**4**	James Wade	10.33	**6**	Rob Cross	12.00
7	Matt Campbell	13.00	**8**	José de Sousa	14.67	**9**	Ryan Meikle	15.00
10	Luke Humphries	15.67	**11**	Michael van Gerwen	16.33	**11**	Danny Noppert	16.33
13	Gerwyn Price	18.00	**14**	Michael Smith	18.33	**15**	Ryan Searle	20.00
16	Josh Rock	21.00	**16**	Ryan Joyce	21.00	**18**	Nathan Aspinall	23.67
19	Ritchie Edhouse	24.33	**20**	Raymond van Barneveld	26.33	**21**	Andrew Gilding	29.67
22	Martin Lukeman	31.67	**23**	Krzysztof Kciuk	33.33	**24**	Joe Cullen	36.33
24	Dimitri Van den Bergh	36.33	**26**	Darius Labanauskas	37.33	**27**	Callan Rydz	38.67
28	Alan Soutar	41.33	**29**	Chris Dobey	41.67	**30**	Mervyn King	43.00
31	Kim Huybrechts	44.67	**31**	Keane Barry	44.67	**33**	Jim Williams	45.33
34	Krzysztof Ratajski	45.67	**35**	Gian van Veen	46.33	**36**	Rowby-John Rodriguez	47.33
37	Kevin Doets	48.67	**38**	Stephen Bunting	50.67	**39**	Jeff Smith	52.67
40	Nathan Rafferty	53.00	**41**	Luke Woodhouse	53.33	**41**	Dave Chisnall	53.33
43	Martin Schindler	54.00	**44**	Joe Murnan	57.67	**45**	Andy Boulton	58.00
45	Scott Mitchell	58.00	**47**	Scott Waites	58.33	**47**	Scott Williams	58.33
47	Vincent van der Voort	58.33	**50**	Brian Raman	61.33	**51**	Dirk van Duijvenbode	62.00
52	Jamie Hughes	63.33	**53**	Ross Smith	66.00	**53**	Mario Vandenbogaerde	66.00
53	Jermaine Wattimena	66.00	**56**	Nick Kenny	66.33	**57**	Gabriel Clemens	66.67
58	Chas Barstow	67.00	**59**	Florian Hempel	68.67	**59**	James Wilson	68.67
59	Shaun Wilkinson	68.67	**62**	Keegan Brown	69.00	**63**	Karel Sedlacek	69.33
64	Adrian Lewis	69.67	**65**	Mike De Decker	71.00	**65**	Lee Evans	71.00
65	William O'Connor	71.00	**68**	Madars Razma	71.67	**69**	Jelle Klaasen	74.00
70	Martijn Kleermaker	74.33	**70**	Mensur Suljovic	74.33	**72**	Cameron Menzies	74.67
73	Robert Thornton	75.00	**74**	John O'Shea	75.33	**75**	Boris Koltsov	76.67
76	Daryl Gurney	77.00	**77**	Max Hopp	78.33	**78**	William Borland	79.67
79	Gary Anderson	80.33	**80**	John Henderson	81.00	**81**	Martin Thomas	81.67

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82	Connor Scutt	83.00	**83**	Andy Hamilton	84.67	**83**	Jason Lowe	84.67
85	Jamie Clark	86.00	**86**	Steve Beaton	86.33	**87**	Radek Szagański	87.33
88	George Killington	88.00	**89**	Maik Kuivenhoven	91.33	**90**	Danny Baggish	91.67
91	Ricardo Pietreczko	92.00	**92**	Geert Nentjes	92.33	**93**	Rusty-Jake Rodriguez	94.67
94	Boris Krcmar	95.67	**94**	Steve Brown	95.67	**96**	Berry van Peer	96.00
96	Jimmy Hendriks	96.00	**96**	Matthew Edgar	96.00	**99**	Justin Pipe	96.67
99	Ian White	96.67	**101**	Niels Zonneveld	97.33	**102**	Steve Lennon	98.67
103	Lewy Williams	99.33	**104**	Ricky Evans	100.00	**105**	Danny van Trijp	100.33
106	Simon Whitlock	101.00	**107**	José Justicia	101.67	**108**	Danny Jansen	103.67
109	Gordon Mathers	104.00	**110**	Mickey Mansell	104.33	**111**	Jason Heaver	105.00
111	Jon Worsley	105.00	**113**	Kai Fan Leung	107.00	**113**	Kevin Burness	107.00
115	Ted Evetts	108.33	**115**	Devon Petersen	108.33	**117**	Geert De Vos	109.00
118	Adam Gawlas	109.67	**119**	Josh Payne	110.00	**120**	Steve West	113.00
120	Ron Meulenkamp	113.00	**122**	Tony Martinez	114.00	**123**	Martin Atkins	115.33
124	Jules van Dongen	115.67	**125**	Aaron Beeney	116.00	**126**	John Michael	116.33
126	Alan Tabern	116.33	**128**	John Brown	116.67	**128**	Jack Main	116.67
130	Zoran Lerchbacher	117.00	**131**	Wayne Jones	117.33	**132**	Jake Jones	117.67
133	Richie Burnett	118.00	**133**	Eddie Lovely	118.00	**135**	Peter Jacques	118.33
136	Stephen Burton	119.00	**136**	Jim McEwan	119.00	**138**	Damian Mol	120.00
139	Luc Peters	120.67	**140**	Jeffrey De Zwaan	121.00	**141**	David Evans	122.00
142	Jesus Noguera	122.67	**143**	Ross Montgomery	123.00	**144**	Pete Burgoyne	123.67
145	Adam Hunt	124.33	**146**	Ryan Murray	126.67	**147**	Derk Telnekes	128.33
148	Bradley Brooks	129.67	**149**	Glen Durrant	132.00	**150**	Darren Webster	132.67
151	Peter Hudson	133.33	**152**	Lisa Ashton	135.33	**153**	Gary Blades	135.67
154	Brett Claydon	139.00	**155**	Nick Fullwell	147.33	**156**	Ciaran Teehan	147.67
157	Michael Rasztovits	155.33						

Source: original work based on: https://tv.dartconnect.com/events/pdc

The table above highlights that Damon Heta emerges as the top player in terms of finishing, as indicated by his consistently high average position across all three sub-rankings. It is important to note that this ranking does not solely reflect the efficiency of hitting doubles (as it would require detailed information about each dart thrown), but obviously there is a correlation here.

By combining the scoring ranking and the checkout ranking, an overall ranking that assesses players based on their performance can be created. It considers players who had a minimum of 300 potential checkout attempts throughout the period (highest-ranked 76 players are presented in Table 8., full ranking is available in .xlsx file).

Table 8. Players Championship 2021 – 2022: Overall ranking of players (Top 76 players).

Rank	Player	Scoring	Finishing	Rank	Player	Scoring	Finishing
1	Jonny Clayton	4	3	**1**	Damon Heta	6	1
3	Michael van Gerwen	2	11	**3**	José de Sousa	5	8
3	Peter Wright	9	4	**6**	Gerwyn Price	1	13
7	Josh Rock	3	16	**7**	Rob Cross	13	6
9	Luke Humphries	14	10	**10**	Michael Smith	11	14
11	Brendan Dolan	29	2	**12**	Danny Noppert	21	11
13	Ryan Searle	19	15	**14**	Nathan Aspinall	17	18
15	Dimitri Van den Bergh	16	24	**16**	Chris Dobey	15	29
16	Joe Cullen	20	24	**16**	James Wade	40	4
19	Callan Rydz	18	27	**20**	Krzysztof Ratajski	12	34
21	Dave Chisnall	10	41	**22**	Raymond van Barneveld	33	20
23	Matt Campbell	50	7	**24**	Dirk van Duijvenbode	7	51
25	Stephen Bunting	22	38	**26**	Andrew Gilding	41	21
27	Jim Williams	31	33	**27**	Alan Soutar	36	28
29	Martin Schindler	24	43	**29**	Gian van Veen	32	35
31	Kim Huybrechts	37	31	**32**	Ryan Joyce	54	16
33	Mervyn King	42	30	**34**	Ross Smith	25	53
35	Ritchie Edhouse	66	19	**36**	Scott Williams	39	47

36	Kevin Doets	49	37	**38**	Gary Anderson	8	79
38	Adrian Lewis	23	64	**40**	Keane Barry	58	31
41	Gabriel Clemens	34	57	**42**	Scott Mitchell	47	45
43	Ryan Meikle	85	9	**44**	Mensur Suljovic	28	70
45	Jermaine Wattimena	46	53	**46**	Jamie Hughes	48	52
46	Rowby-John Rodriguez	64	36	**48**	Luke Woodhouse	60	41
49	Daryl Gurney	27	76	**50**	Florian Hempel	45	59
50	Darius Labanauskas	78	26	**52**	Mario Vandenbogaerde	53	53
53	Mike De Decker	43	65	**53**	Vincent van der Voort	61	47
55	Cameron Menzies	38	72	**56**	Krzysztof Kciuk	90	23
57	James Wilson	55	59	**58**	Andy Boulton	72	45
59	Martin Lukeman	96	22	**60**	William O'Connor	57	65
61	Scott Waites	76	47	**62**	Ian White	26	99
63	Karel Sedlacek	67	63	**64**	Steve Lennon	30	102
65	Jason Lowe	51	83	**66**	Lee Evans	70	65
67	Madars Razma	69	68	**67**	Joe Murnan	93	44
67	Nathan Rafferty	97	40	**70**	Boris Krcmar	44	94
71	Keegan Brown	77	62	**72**	Simon Whitlock	35	106
73	Chas Barstow	86	58	**73**	Jeff Smith	105	39
75	Rusty-Jake Rodriguez	52	93	**75**	Maik Kuivenhoven	56	89

Source: original work based on: https://tv.dartconnect.com/events/pdc

The table above displays data regarding the players' rankings in scoring and finishing. The first place is shared by Jonny Clayton and Damon Heta, as their average rank is the lowest at 3.5. While it is generally assumed that high-scoring correlates with finishing ability, this relationship is not always guaranteed. Nevertheless, the current rankings seem to support common opinions about certain players. James Wade, for instance, is renowned for his exceptional finishing skills but does not exhibit the same level of brilliance in scoring - as reflected in the ranking. Brendan Dolan is another player perceived similarly. Conversely, Dave Chisnall, Simon Whitlock and Gary Anderson are known for their excellent scoring capabilities, yet their finishing skills are considered less remarkable. Gary Anderson's case is particularly peculiar, as he ranks 8th in scoring but only 79th in finishing.

Based on the provided rankings, the players have been categorized into five groups according to their final positions:

1. Players in the Top 15 (e.g., Jonny Clayton, Michael van Gerwen, Dimitri Van den Bergh, etc.),
2. Players ranked 16 – 40,
3. Players ranked 41 – 70,
4. Players ranked 71 – 110,
5. Players ranked 111 – 157.

Table 9. Number of collected situations for individual groups of players.

	Number of situations	**Including: possible to finish**
Top 15	112.887	30.865
16 - 40	149.642	40.373
41 - 70	147.461	38.096
71 - 110	147.761	37.667
111 - 157	128.444	31.051
Others	29.009	6.906
SUM	715.204	184.958

Source: original work based on: https://tv.dartconnect.com/events/pdc

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Although the chosen boundaries for these groups are somewhat arbitrary, an effort was made to ensure a slightly larger number of players in each successive group. Lower-ranked players generally have fewer opportunities to play games, so the selected ranges had to be wider to gather sufficient data.

As indicated in the table, the ranges in terms of volume are relatively close to each other. The "*others*" category in the table includes darters who played too few matches to be categorized.

With the initial statistics now compiled, it is high time to analyse the impact of pressure on the performance of the top players.

RESULTS

In the study, the effect of pressure on players' efficiency will be examined in two ways:

1) Tests of proportions will be conducted for extreme cases, comparing the frequency of successful checkouts in the absence of pressure to those under maximum level of pressure.
2) Cochran-Armitage tests will be utilized to investigate the presence of a linear relationship between the level of pressure and the success rate.

Table 10. An exemplary set of situations.

.xlsx row	Points scored	Opponent's counter	Decider?	Successful checkout?	Group of checkouts - player	Group of checkouts - opponent	Level - player
3510	57	201	No	No	10 – 25%	0%	Top 15
3512	64	141	No	Yes	40 – 50%	3 – 10%	Top 15
3520	137	145	No	No	0 – 3%	3 – 10%	Top 15
3522	24	20	No	Yes	> 70%	> 70%	Top 15
3540	118	25	No	Yes	10 – 25%	50 – 70%	Top 15
3549	66	28	No	Yes	40 – 50%	> 70%	Top 15
3559	50	36	No	No	40 – 50%	> 70%	Top 15
3561	12	18	No	No	> 70%	50 – 70%	Top 15
3571	81	139	No	Yes	25 – 40%	3 – 10%	Top 15
3589	28	64	No	Yes	> 70%	40 – 50%	Top 15
7549	59	170	no	No	25 – 40%	0 – 3%	Top 15
7551	25	25	No	Yes	50 – 70%	50 – 70%	Top 15
7561	36	32	No	Yes	> 70%	> 70%	Top 15
7570	18	104	No	No	50 – 70%	10 – 25%	Top 15
7579	108	36	No	No	10 – 25%	> 70%	Top 15
7589	58	198	No	No	10 – 25%	0%	Top 15
7591	48	140	No	Yes	50 – 70%	3 – 10%	Top 15
7601	74	5	No	No	10 – 25%	50 – 70%	Top 15
7603	32	2	No	Yes	> 70%	50 – 70%	Top 15
7610	100	184	No	No	0 – 3%	0%	Top 15
7612	70	84	No	Yes	40 – 50%	25 – 40%	Top 15
7622	80	117	No	No	25 – 40%	10 – 25%	Top 15
7624	20	20	No	Yes	> 70%	> 70%	Top 15

Source: original work based on: https://tv.dartconnect.com/events/pdc

In the case of checking the checkout efficiency under two types of situations (e.g., high-pressure situations and low-pressure situations), it was necessary to involve the same players in both scenarios. Although this may seem unusual, it is a result of the specific nature of the study. Darts players are regularly confronted with various situations. Within a single game, each player usually encounters both high and low-pressure

situations. These occur alternately, depending on the course of the game. To analyse the impact of pressure on players' performance, it was necessary to compare their achievements in different conditions. This approach was chosen to precisely assess their efficiency under varying pressure contexts. Additionally, using the same players, the confounding factor of individual differences is eliminated. However, it should be noted that this research methodology is unique and stems from the distinctive nature of the study. To provide context, Table 10. presents a compilation of exemplary situations in which Jonny Clayton, one of the leaders of the ranking mentioned earlier, was the player at the dartboard. The data is sourced from an .xlsx file, which is available for download.

Although the data above comes from just two matches, it is noteworthy how the player encountered a variety of levels of pressure.

It is also worth noting that studies conducted in the field of darts do not allow for a definitive determination of whether the level of pressure certainly should affect players positively or negatively. Therefore, the conducted tests will be two-tailed, examining both the positive and negative impact of additional pressure. Due to the large amount of available data, a significance level of .05 will be applied for hypothesis testing.

Darts and "tilting"

Before proceeding with the main analysis, it is worth considering a phenomenon in darts that can be likened to "*tilting*" in poker. Tilting refers to moments of emotional upset where a poker player makes irrational decisions influenced by past failures (Torrance et al., 2022). In the context of darts, whether similar emotional factors affect players' performance can also be examined. In darts, there are instances where players struggle to hit even the simplest doubles, despite having multiple attempts. This raises the question of whether emotional upset, similar to tilting in poker, can make it difficult for a player to finish the leg successfully in subsequent attempts. In other words, it should be explored whether misses in previous visits significantly impact a player's ability to hit doubles in subsequent attempts within the same leg. If emotional factors, or "*tilting*" as it is understood here, are indeed important, then observations where players cannot close simple values for several attempts will not be independent. The influence of previous missed attempts can affect subsequent ones, potentially distorting performance results and leading to incorrect conclusions. This is particularly relevant when analysing situations where both players are already on low values, as their mistakes can collectively reduce effectiveness in that specific group of situations (e.g., both players failing to finish 40 points in six attempts). However, it is crucial to differentiate between tilting and independent events driven by probability. Sequential failures can occur regardless of emotional factors, merely as a result of probability. Therefore, it is essential to determine the cause behind these events. If the cause is not tilting, the situations can be considered independent of each other. Consequently, the ultimate question to address is whether the efficiency statistics in situations where both players have low values will be artificially lowered due to tilting.

The examination of the aforementioned problem involves comparing the efficiency of players in two different scenarios:

a) Suspected tilting situations: these are situations where a player, in a previous visit to the same leg, failed to close a value from the first group (e.g., 24, 32 or 40).
b) Other situations: these include other cases where a player has a value from the first group to finish.

If the efficiency is significantly different in the first group of situations, it would indicate that the failure to close a low value in a given leg reduces the probability of successfully finishing the leg in subsequent attempts. The results of efficiency are presented in Table 11. Only situations where players had a value from group I

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on the counter were considered for these results. One group comprises suspected tilting situations, while the other group encompasses all other scenarios.

Table 11. Comparison of checkout efficiency in situations suspected of "*tilting*" and in other situations (I group of values).

	Efficiency		
	Potential "*tilting*" situations	"*Normal*" situations	Attempts
Top 15	79.26%	80.26%	6956 (487 + 6469)
16 - 40	75.25%	77.24%	9167 (788 + 8379)
41 - 70	76.34%	75.63%	8267 (672 + 7595)
71 - 110	73.88%	73.55%	8036 (716 + 7320)
111 - 157	72.62%	71.70%	6457 (716 + 5858)
Others	67.53%	68.96%	1449 (1295 + 154)
Average	74.94%	75.54%	40332 (3416 + 36916)

Source: original work based on: https://tv.dartconnect.com/events/pdc

The data indicates that there is no significant difference in efficiency between "*suspicious*" situations and "*normal*" situations. In fact, the efficiency in suspected tilting situations is even higher in some groups. Based on this, it can be assumed that within a given leg, failing to hit an easy double does not decrease the likelihood of hitting a double on the next visit. To confirm this, a parametric test for proportions can be conducted using the Z statistic to compare two large independent samples. This test will determine if the difference between the results of the two groups is statistically significant. The number of attempts is relatively equal for each group (except for the group on unclassified players), so the total number of occasions for all groups will be considered. In this case, the hypotheses are as follows:

- Null hypothesis: there is no difference between the proportions in the two groups,
- Alternative hypothesis: there is a difference between the proportions in the two groups.

The Z statistic in this case is calculated as -0,7768 (p = .437). Therefore, there is insufficient evidence to reject the null hypothesis at a significance level of .05. The small difference in proportions is also the main cause of the low power of the conducted test ($1 - \beta = 0.12$). *This means that in this case, there is a high risk of committing a Type II error. However, in such a situation, the question automatically arises regarding the practicality of detecting such small differences. Let's assume that in objective reality, in situations suspected of tilting, players indeed have a slightly lower efficiency, for example, by 0.6 percentage point, but the test was unable to detect it (huge sample sizes would be required for such differences). However, in the context of darts, such a difference is unimportant, and its practical consequences are essentially zero. Considering the scale, the potential occurrence of a Type II error seems to be a marginal issue in this case.*

Just to mention: it does not imply the absence of good or bad series of darts. The conclusion drawn is that, based on the performed analysis, the data does not seem to be artificially influenced by potential tilting.

The level of pressure exerted by an opponent and the checkout efficiency – tests of proportions for extreme cases

An analysis of two types of situations was conducted to examine the effect of pressure on the checkout efficiency. The two types of situations considered are as follows:

- High-pressure situation: in this scenario, the thrower and the opponent both have a value from group I to finish,
- Zero-pressure situation: in this case, the player has a value from group I, while the opponent would be unable to finish even if they returned to the board.

Each set of situations was analysed separately for each group of players. For each set, a test of proportion based on the Z-statistic was conducted to determine if the difference in average efficiency of finishing between the two cases was statically significant. The results of these tests are presented in Table 12.

Table 12. Checkout efficiency in high and low-pressure situations – results of tests of proportions for individual groups of players.

	Efficiency		Attempts		Tests of proportions	
	Player: > 70%. Opponent: > 70% (High pressure)	Player: > 70%. Opponent: 0% (Low pressure)	Player: > 70%. Opponent: > 70% (High pressure)	Player: > 70%. Opponent: 0% (Low pressure)	Z-score	*p*-value
Top 15	78.92%	80.69%	1954	751	-1.023	.305
16 - 40	76.15%	76.27%	2763	906	-0.073	.941
41 - 70	74.64%	75.67%	2662	670	-0.548	.583
71 - 110	73.24%	75.58%	2724	602	-1.181	.237
111 - 157	70.74%	70.33%	2273	428	0.173	.862

Source: original work based on: https://tv.dartconnect.com/events/pdc

For each of the analyses, two hypotheses were formulated:

- Null hypothesis: there is no difference in checkout efficiency between the two types of situations,
- Alternative hypothesis: there is a difference in checkout efficiency between the two types of situations.

According to the conducted test, the observed differences for neither group were big enough to be considered statistically significant. Therefore, the tests of proportions did not provide compelling evidence to conclude that the high level or pressure exerted by the opponent influences the probability of the thrower hitting a double. However, it is worth noting that for 4 out of 5 groups, the efficiency in high-pressure situations was marginally lower, with differences ranging from 0.12 to 2.34 percentage points. Additionally, the power of the conducted tests was again very low, ranging from 0.05 to 0.23. Despite a relatively large number of observations in each case, the differences were so small that they cannot be considered statistically significant. However, this raises the question once again – would rejecting the null hypothesis with such a small effect size have any real significance? The sample sizes are relatively large, and the results were similar across all groups, suggesting that increased samples could indeed increase the power of the test and potentially demonstrate statistical significance, but the proportions themselves should not change significantly. This, in turn, would indicate a very minimal, negative impact of pressure on players' efficiency, particularly considering that extreme situations were compared. This impact may not be zero, but it is so low that it can be deemed marginal.

Furthermore, it will be useful to also explore the potential impact of pressure resulting from the state of the match, specifically the current result. In this case, high-pressure situations occur in final legs, typically at scores of 5-5, 6-6 or 7-7, depending on the phase of the tournament. However, there is a significant disparity in the sample sizes, as deciding legs (deciders) are relatively rare. Over the two-year duration of the tour, nearly 185,000 checkout attempts were recorded, but only around 4,500 took place in deciders. Therefore, in this context, only the success rates will be compared based on the remaining value on the counter, without further breakdown by groups of players (which would be also irrelevant in this case). A comprehensive summary, including the tests of proportions conducted using the Z-statistic, is provided in Table 13.

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Table 13. Checkout efficiency in deciding legs compared to efficiency in other cases.

	Deciding legs			Other legs			Tests of proportions	
	Successful attempts	Unsuccessful attempts	Efficiency	Successful attempts	Unsuccessful attempts	Efficiency	Z-score	*p*-value
> 70%	743	252	74.67%	29702	9635	75.51%	-0.603	.546
50 - 70%	392	264	59.76%	15668	9729	61.69%	-1.007	.314
40 - 50%	170	249	40.57%	7494	9052	45.29%	-1.917	.055
25 - 40%	172	373	31.56%	7732	14929	34.12%	-1.247	.213
10 - 25%	114	593	16.12%	5060	24702	17.00%	-0.614	.539
3 - 10%	50	714	6.54%	1759	28614	5.79%	0.879	.379
0 - 3%	11	369	2.89%	411	16005	2.50%	0.482	.63
In overall	1652	2814	36.99%	67826	112666	37.58%	0.801	.423

Source: original work based on: https://tv.dartconnect.com/events/pdc

With the following hypotheses:

- Null hypothesis: there is no difference in checkout efficiency between the two types of situations,
- Alternative hypothesis: there is a difference in checkout efficiency between the two types of situations.

The results of the concluded tests do not provide sufficient evidence to reject the null hypothesis in favour of the alternative hypothesis. This conclusion applies to each group. Therefore, the statistical analysis does not indicate any statistically significant impact of the additional pressure resulting from the deciding legs.

The level of pressure exerted by an opponent and the checkout efficiency – the Cochran-Armitage test

In one of the previous analyses, only two extreme types of cases were examined: situations with maximum and minimum levels of pressure. However, there exist numerous other scenarios between these extremes. For instance, the finishing player may be set on the easiest double, while the opponent's remaining score indicates a possible but less probable finish (e.g., 120). In such cases where the variables are categorical (e.g., yes / no, hit / missed) and the categories of variables are ordinal (e.g., high pressure, medium pressure, low pressure), the Cochran-Armitage test can be utilized to determine if there is a linear relationship between the proportions in each category (Kwasiborski & Sobol, 2011). The test itself does not determine the direction of the trend, but this issue will be addressed a bit later.

When examining the checkout efficiency at various levels of pressure, it is reasonable to expect that the level of pressure imposed will increase as the opponent's remaining score decreases. In other words, the level of pressure can be ranked according to the group into which the opponent's value falls at any given time. For example, a value of 40 on the opponent's counter would be categorized as group I, indicating a very high level of pressure. On the other hand, a value of 90 might be considered as medium pressure. To illustrate this point, Table 14. presents the checkout efficiency of the Top 15 players at different levels of pressure (all tables are available in .xlsx file).

It is worth noting, however, that the analysis of efficiency will only consider data from the first three groups of values from the thrower's perspective (represented by the blue bar to the left side of the table), as indicated by the data highlighted in green in the table. This is because, in these specific value ranges, it can be assumed that the player is fully committed to finishing the leg during that particular turn. This commitment is not as apparent in other cases. To illustrate this issue, let's consider a scenario where the player has 90 points to close (group IV), and their opponent has 151 points remaining on the counter. In such a situation, it is likely that the thrower will not attempt to close the leg at any cost, but instead may consider setting

themselves up comfortably on a double. For example, instead of starting the turn with 20s (to potentially leave a bull's-eye finish with the last dart), the thrower might choose to start with 18s, which reduces the chance of setting up the finish, but, given the opponent's low chance of successfully finishing, allows for a more comfortable setup in the next turn. Additionally, in this case, the 0 – 3% and 0% groups will be combined due to the limited number of observations in the 0 – 3% range.

Table 14. Checkout efficiency by Top 15 players based on the level of pressure.

		Group – opponent								
Top 15		> 70%	50 - 70%	40 - 50%	25 - 40%	10 - 25%	3 - 10%	0 - 3%	0%	Attempts
		High pressure			Medium pressure			Low pressure		
Group – player	> 70%	78.92%	79.81%	80.17%	80.87%	80.88%	81.31%	88.19%	80.69%	6956
	50 - 70%	66.67%	68.90%	65.08%	64.10%	60.41%	63.69%	70.59%	65.13%	4422
	40 - 50%	50.35%	52.38%	52.08%	57.14%	48.49%	54.73%	47.83%	52.72%	2813
	25 - 40%	39.67%	40.61%	43.00%	41.43%	40.85%	43.39%	37.91%	36.05%	4001
	10 - 25%	22.71%	25.15%	18.98%	25.00%	25.98%	20.24%	17.39%	14.19%	4977
	3 - 10%	7.37%	8.27%	9.38%	8.45%	8.41%	8.78%	10.26%	8.08%	4782
	0 - 3%	3.18%	3.20%	2.17%	4.45%	5.52%	5.04%	5.20%	2.11%	2914
	Attempts	**6557**	**5057**	**2516**	**2765**	**3432**	**3029**	**1038**	**6471**	

Source: original work based on: https://tv.dartconnect.com/events/pdc

Therefore, the analysis will test the presence of a linear relationship between pressure level and efficiency within the seven groups ranked according to pressure level. These groups are categorized as follows: group I – opponent waiting on a value from the group > 70% (high pressure), group VII – opponent waiting on a value from the group < 3% or 0% (low pressure). The results of the analyses are presented in Table 15.

Table 15. Checkout efficiency and level of pressure exerted by the opponent – analysis based on Cochran-Armitage tests.

	Does level of pressure impact checkout efficiency?								
	Checkout attempts: group of values: > 70%			Checkout attempts: group of values: 50 – 70%			Checkout attempts: group of values: 40 - 50%		
Group of Players	Chi-square value	*p*-value	Attempts	Chi-square value	*p*-value	Attempts	Chi-square value	*p*-value	Attempts
Top 15	4.255	.039*	6956	3.193	.074	4422	0.374	.541	2813
16 - 40	0.088	.766	9167	0.127	.91	5674	0.011	.918	3681
41 - 70	5.262	.022*	8267	3.026	.082	5317	0.049	.825	3611
71 - 110	0.606	.436	8036	0.034	.853	5328	0.912	.34	3443
111 - 157	0.265	.607	6457	0.545	.46	4346	2.478	.115	2812

Source: original work based on: https://tv.dartconnect.com/events/pdc
*Note. * Indicates cases for which p < .05 (indicating statistical significance).*

The analysis of each individual case includes a minimum of 230 situations. The lowest number of observations occurred for players ranked 111 – 157 in the value group of 50 – 70%, where the opponent's value fell within group 3 – 10%. Conversely, the highest number of observations was recorded for players ranked 16 – 40 in the value group > 70%, where the opponent's value also fell within group > 70%.

For the aforementioned analysis, the following hypotheses are considered:

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- null hypothesis: there is no linear relationship between the level of pressure and the checkout efficiency,
- alternative hypothesis: there is a linear relationship between the level of pressure and the checkout efficiency.

The results of the analysis for different groups of values are as follows:

1. Closing values with a probability > 70% (group I): at a significance level of .05, a linear relationship between checkout efficiency and the level of pressure imposed by the opponent was observed for two out of five groups of players. In both cases, the direction of this relationship was consistent, indicating that higher pressure leads to lower efficiency. No such relationship was observed for the other three groups of players.
2. Closing values with a probability between 50% and 70% (group II): the relationship between efficiency and the level of pressure was not statistically significant for any of the groups of players, although the p-value for the Top 15 group was 0.074.
3. Closing values with a probability between 40% and 50% (group III): the relationship between efficiency and the level of pressure was not statistically significant for any group of players.

In summary out of the 15 sub-analyses, there were grounds to reject the null hypothesis in favour of the alternative hypothesis in only two cases. Based on these findings, there is insufficient evidence to conclude that there is a linear relationship between pressure level and checkout efficiency among professional players.

Although Cochran-Armitage tests did not provide information about the direction of the trend, it can be examined using simple linear regression. In 10 out of 15 cases, the slope coefficient of the line had a positive value, while in the remaining cases, it had a negative value. However, disregarding the very low values of the coefficient of determination (R-squared) in most cases, it is even difficult to provide a definitive answer as to whether increased pressure would have a positive or negative impact on a player's performance (data is available in .xlsx file).

DISCUSSION AND CONCLUSIONS

Both the analysis of extreme cases using tests of proportions and the analysis of linear relationship using Cochran-Armitage tests failed to provide sufficient evidence to indicate a statistically significant effect of pressure on the playing performance of professional darts players. The data also does not suggest a significant impact of pressure when playing in the deciding leg of the match. However, the issue of power in the conducted tests remains somewhat problematic, particularly in the case of tests of proportions. The differences in performance between the examined situations were so small that even with a large database of data, detecting them proved to be unlikely. On the other hand, regularly recurring such small differences indicate that increased pressure does not have such an impact on players' efficiency that would have any real significance.

These findings align with the conclusions of a study published in the article "*Performance under pressure in skill tasks: An analysis of professional darts*" (Ötting et. al., 2020), in which the authors analysed over 32,000 throws into a dartboard. Both the present work and the cited article demonstrate the remarkable mental toughness displayed by top players in the world. The opinions expressed in the introduction seem to be supported by reality, highlighting the necessity for players to possess high level of composure, concentration and overall mastery of the situation to compete at the highest level and overcome additional pressure factors.

However, it is important to acknowledge that the investigation into the impact of pressure on the playing quality of top darters is still far from complete. While the Players Championship series is widely recognized for its prestige and gathering of the world's best players, certain characteristics should be taken into account, such as low number of broadcasted games, the lack of fans in the venue and relatively lower stakes compared to the most significant tournaments worldwide. It is not certain that the study's results would have been the same if the data had been sourced from tournaments played on the stage, surrounded by TV cameras and passionate fans. Further exploration of the topic is warranted, encompassing more than just Players Championship games. However, it should be noted that other tournaments may suffer from limited amount of data. For instance, two years of Players Championship games accounted for over 7,500 matches, whereas the more prestigious European Tour only comprises approximately 1,200 in such a time interval. Given the wide range of potential scenarios, this may be insufficient in some cases.

Moreover, it is essential to acknowledge that the concept of pressure has been narrowly addressed in the present work. Pressure originates not only from the opponent's situation but also from factors such as the tournament phase or the quality of the opponent faced by the player. Thus, future research on the topic should encompass a broader examination of other pressure-inducing factors that have not been considered here. Players do not seem to be bothered by this particular kind of pressure, but this conclusion cannot be considered as universal.

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