Mental toughness: Packers using non-physical part of football for knowledge

By Michael Cohen

Oct 17, 2018

Back in September, as the Green Bay Packers prepared for their season opener against the Chicago Bears, rookie inside linebacker Oren Burks was still recovering from a dislocated shoulder suffered in training camp. The medical staff nixed Burks' participation in the more physical portions of practice and strapped a harness beneath his pads for protection. There were no limits, however, on what he could do with his mind.

Which is why Burks, a third-round pick from Vanderbilt, hovered behind starting linebackers Blake Martinez and Antonio Morrison during the walkthrough that begins each practice. He mimicked their movements to picture himself against the Bears even though his shoulder would need two more weeks to heal.

"Walkthrough helps so much in terms of slowing it down, and then you can really work on your eyes and your techniques," Burks said. "So I'm taking on this block this way and you can see, you're visualizing yourself. So when it goes fast (in a game) it's not foreign, and you're not like, 'Oh, snap!'

"Instead you're just like, 'I've done this before,' and it's just muscle memory. It's cool."

Anyone who has attended organized team activities, minicamp or training camp has seen the Packers dedicate significant amounts of time to walkthroughs on Ray Nitschke Field, where the actions seem equal parts monotonous and rudimentary. After all, there is minimal excitement ascribed to half-speed installations against faux opponents.

But there's a method to the madness, even if players and coaches aren't always familiar with the scientific principles behind it. At their core, walkthroughs fall beneath a broad umbrella encompassing the cognitive aspects of preparation, an enclave that already includes film study, mental reps and classroom sessions at Lambeau Field. This is the non-physical part of football referred to by defensive run-game coordinator and inside-linebackers coach Patrick Graham as the "gigabytes." And across all sports, players with larger databases of knowledge have been proven to anticipate more effectively during games.

"It's a big focus this year, no different than any other year," coach Mike McCarthy said during training camp. "We try to expand our cognitive creativity."

What's easy to forget, though, is that watching film and reading keys are skills that must be developed in the same way outside linebackers practice spin moves and wide receivers perfect

releases off the line of scrimmage. Because no matter how remarkable a player's athletic gifts may be, comprehension represents acquired knowledge triggered by uncountable hours of dedication and study.

That is how the mental side of football works. That is how "gigabytes" are acquired.

"Because it's too easy to kind of dismiss these super athletes as just natural specimens of greatness," said Joe Baker, a professor in the School of Kinesiology and Health Science at York University, during a phone interview. "When you start to break it down it's like, no, this is all learned stuff. These are all things that they've devoted their time and their practice to learning, and that's why they're so good."

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Advancements in wearable technology have brought to life the cat-and-mouse games between quarterbacks and defenders at the line of scrimmage, with pre-snap dialogue now broadcast to fans watching at home. Last December, microphones captured a conversation between Packers linebacker Clay Matthews and Carolina Panthers quarterback Cam Newton, whose verbal duel unfolded as the play clock ticked.

"It's that wheel route! It's that wheel route!" Matthews shouted to his fellow defenders, warning them about tailback Christian McCaffrey, who flanked Newton in the backfield. "I study, too!"

"You've been watching film, too, huh?" Newton responded, pointing at Matthews. "That's cool. Watch this," and the Panthers quickly scored on a short pass to McCaffrey over the middle, a tweak to what Matthews had expected.

The stop-and-start nature of football poses different mental challenges from sports like basketball, hockey and soccer, where the run of play is more continuous and fluid. In football, where each play has a distinct beginning with the offense and defense facing each other, there are strategic battles at the line of scrimmage in search of a pre-snap edge. Quarterbacks scan the field to make predictions based on alignments of opposing players, while linebackers respond accordingly. Both sides draw from patterns they've identified on film about what the pre-snap locations of players indicate about the offense or defense.

A heightened understanding of the spatial relationships on a football field is derived from the findings of two 20th-century studies that explored the recall of chess players. The first study, conducted in the 1940s by Dutch chess master and psychologist Adriaan de Groot, asked players of varying abilities to recreate an entire board after viewing the pieces for just a few seconds. The second study, published in 1973 by William G. Chase and Herbert A. Simon, two psychologists from Carnegie Mellon University, repeated the original experiment while also including a control that tested the players' recall with random arrangements of pieces not possible in an actual game.

Both experiments showed that players with greater experience fared drastically better than average players when reconstructing boards with logical arrangements of pieces, even with only

brief glimpses at the original alignment. But Chase and Simon also found that experience meant nothing when players were asked to recreate the random arrangements. In those scenarios, when the pieces were placed in illogical positions, the masters' recall was no better than players with far less ability.

"Hence, the masters appear to be constrained by the same severe short-term memory limits as everyone else," Chase and Simon wrote, "and their superior performance with 'meaningful' positions must lie in their ability to perceive structure in such positions and encode them in chunks."

In the decades since that experiment, the concept of chunking has been applied to many different disciplines. Chunk theory explains how people learn to read, according to Baker, with children taught to view words as recognizable patterns rather than strings of letters. It's also how people memorize phone numbers by breaking them down into small groups with a few digits in each.

David Epstein, a former senior writer at Sports Illustrated, explained the connection between chunk theory and athletics in his 2013 book, "The Sports Gene":

"Chess masters and elite athletes alike 'chunk' information on the board or the field. In other words, rather than grappling with a large number of individual pieces, experts unconsciously group information into a smaller number of meaningful chunks based on patterns that they have seen before. Whereas the average club player in de Groot's study was scanning and attempting to remember the arrangement of twenty individual chess pieces, the grandmaster needed to remember only a few chunks of several pieces each, because the relationships between the pieces had great meaning for him."

From there, it becomes easier to understand exactly what happened during the exchange between Matthews and Newton last season. When studying film, Matthews had seen the Panthers run a wheel route from the same alignment they showed before their matchup with the Packers. His brain had noted the spatial relationships between the running back, tight end and wide receivers — not unlike a chess master logging a certain quadrant of the board — and then extracted that information when the same pattern presented itself in person.

It means football players build a catalog of alignments and formations the way chess players memorize known combinations of pieces.

"The interesting thing about that is, again, if you change any of those parameters, if you remove the structure of the performance, the ability goes away," Baker said. "It seems like it's 100 percent related to the experience that they have (in their specific sport or activity), not an innate ability to recall structured patterns of information.

"We did a really cool study in the '90s where we had basketball players look at patterns of field hockey, which they're both kind of invasion sports where you have to move into the other team's area and score. There was a little bit of crossover between the experts, but for the most part, they looked like just like novices when you change those patterns of performance."

After hearing about the chess experiment, several Packers players identified examples of chunking for their respective positions:

Wide receiver Davante Adams said he spends the seconds before each snap studying the opposing defensive backs to his side of the field, racking his brain for information about what the alignment of those players says about the coverage they're playing:

"You see where the safety is. If he's over the top of my corner but my corner is pressed, he's bluffing because I know the safety is not going to be in that position. If (the safety) has to go to the middle of the field, he's way too far over (toward) me. So obviously (in that situation) the corner is going to blitz and (the safety) is going to replace where he was because there's always a reason.

"Everybody can't disguise, otherwise you wouldn't be able to get to the spots (in time). So the more you know and the more you can kind of use those keys, the faster you can play."

Cornerback Davon House, who has since been put on injured reserve with a shoulder problem, said there are times when he can recognize coverages based solely on where certain players are aligned, even if he never sees the entire field:

"For example, if we took the safeties out of the equation — so the safeties are gone — and all I see is two corners and I see that they're 5 yards off (the line of scrimmage), I know that we're in Cover 2. You can do that with a lot of stuff in football."

And Burks said he's begun studying larger trends across the NFL in an effort to diagnose plays more quickly during games:

"You'll watch a game you never watched before and kind of anticipate like, all right, based on this formation this is generally what the league likes to do. Different teams pick up on tendencies like that, so there's some stuff that rings true for the whole league, there's some stuff that's very specific to the opponent that you're playing. It changes week to week."

In other words, there's a direct correlation between hours spent watching film and how quickly a player's database expands. A larger pool of football knowledge — aka more "gigabytes" — equates to increased anticipation on the field.

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Of course, any static comparisons between football and chess evaporate the moment a ball is snapped, at which point defenses shift and offenses introduce new wrinkles unseen on film. That's why defensive coordinators spend so much time disguising their intentions while offensive coordinators design multiple plays from the same formation. Surprising the opposition is a great way to make the brain short-circuit, just like Chase and Simon proved with their random arrangements of chess pieces.

So what types of knowledge do players rely on after the play begins? How does the brain respond when the chess board kick-starts into motion?

For Burks, who has returned from injury to become Martinez's primary sidekick at inside linebacker, the primary objective is to maximize his understanding of an opponent's initial movements. Burks said he watches the first half-second of each play repeatedly on his team-issued iPad to recognize how those early movements correspond to specific plays. He wants to know what it means when a running back moves laterally as the ball is snapped. He's curious what happens when an offensive lineman's first step is backward rather than forward.

Are there connections between these tiny movements and the result of a given play that, if read properly, allow defenders to diagnose what's happening more quickly?

"That's what we watch in film," Burks said. "It's getting those initial keys so you visualize yourself like, all right, in this position this is where my eyes would be. It's on his right hip, or something very specific and just kind of going off of that."

The indicators players and coaches look for are known as advanced cues, which refer to "any aspect of the behavior of an opponent — in particular their body language or body movements, (which we) call kinematics — that can be used to anticipate their action," wrote Rob Gray, an associate professor in human systems engineering at Arizona State University.

It's a concept that crosses the boundaries of sports, from pitchers who accidentally tip their pitches in baseball to point guards who telegraph their passes in basketball, from tennis players reading the direction of a serve to goalkeepers anticipating the direction of a penalty kick in soccer. Athletes who recognize these cues faster have a better chance of succeeding in their respective discipline.

(Gray dedicated an episode of his show, "The Perception & Action Podcast," to the topic. You can check it out here.)

This type of expertise has been studied for decades using variations of the occlusion method, developed in 1975 by Janet Starkes, who was then a graduate student at the University of Waterloo, and later expanded on by Bruce Abernethy, who is now the executive dean for the Faculty of Health and Behavioural Sciences at the University of Queensland and the leading researcher in the field.

Burks' obsession with the first half-second of a play is a modified version of an occlusion test.

"I think that's exactly what he's trying to pick up, the very early-on kind of information telling you this kind of play is happening or this is going to happen is really what it's all about," Gray said in a phone interview. "What he's doing is kind of his own version of the occlusion method where we only show you part of the unfolding action and you have to try and anticipate based on that.

In its simplest form, an occlusion test shows athletes part of an action — be it a tennis serve, a volleyball spike, a baseball pitch or a soccer kick — and blocks from a view a portion of that particular movement. Abernethy's experiments have used video clips of cricket bowlers that cut off before the pitch is delivered; tennis players wearing goggles that cloud their vision as an opponent prepares to hit the ball; and cricket batters with contact lenses designed to be blurry, according to Epstein, who chronicled Abernethy's contributions to the field in his book.

With each experiment, athletes were asked to predict what happened based on the fraction of information available to them. Advanced cues were their tools for anticipation. This is known as predictive skill.

"The theme of Abernethy's findings is that elite athletes need less time and less visual information to know what will happen in the future, and, without knowing it, they zero in on critical visual information, just like expert chess players," Epstein wrote.

"Top tennis players, Abernethy found, could discern from the minuscule pre-serve shifts of an opponent's torso whether a shot was going to their forehand or backhand, whereas average players had to wait to see the motion of the racket, costing invaluable response time."

Graham seeks to expand his players' databases slowly, in a manner reflective of the science behind both the chess and occlusion studies. He begins his film sessions with the screen paused — a la chess — looking only at the down and distance for each play, educating his linebackers about what they can expect based on situation alone. From there, he expands to technique and eye movement, explaining where each player should direct his vision on a given snap. Next come formational clues gleaned from the splits between receivers or the starting positions of offensive linemen.

His overall goal is to "eliminate the variables" by explaining how to reduce the number of options an offense has for a particular play, and in turn, this allows linebackers to exercise their predictive skill. Graham navigates the tape in piecemeal fashion, not unlike Abernethy's experiments and Burks' fascination with reading an opponent's first movement.

"You have to understand what you're up against," Graham said. "Especially on defense you're up against an offensive line coach who, you talk to any coach, he's usually one of the best coaches on the staff. They go over stuff, they're meticulous about the preparation. … So you've got one of the best coaches on the staff, doesn't have anything to do but his family and football, studying you like that. I said (to my players), 'You better get an edge because I'm guaranteeing he's getting the edge on you.'

"I have nothing else to do but football and my family. That's it. I have no hobbies. I don't have anything else to do. I think once they start to understand that and understand how people are studying them and stuff, they start to understand the importance."

In fact, there is an ongoing challenge between Graham and his players that tests the coach's recall. Graham, 39, was born and raised in Connecticut and played on the defensive line at Yale University, where he earned a sociology degree with concentrations in economics and African-

American studies. He gained the bulk of his NFL experience with the New England Patriots from 2009-'15, coaching linebackers and the defensive line, before joining the Packers in January.

Graham's personal "gigabytes" are incredible, according to Burks, and he encourages players to test him by asking detailed questions about any game from his career. The linebackers can identify random situations from a given game — the first play of the opponent's fifth possession in a certain Super Bowl with the Patriots, for example — and Graham recalls the situation in vivid detail.

"He can remember like pretty specifically," Burks said. "Working on our technique or something like that, he'll be like, 'Yeah, this is how you need to take on the block, you need to press it,' or something like that. And then he'll go back and pulls the game up, play 13, and goes right to the end-zone copy and then, sure enough, they're pressing and doing the technique.

"For me, I'm still trying to pick up on the defense and you'll gradually get there. But it's just like day to day, putting in the work, it's kind of like getting the mental reps like you're talking about."

How much and how quickly players expand their reservoirs of knowledge is dependent in part on the individuals themselves. For as much film as players watch in meetings during the week, the majority of studying must be done on their own outside of the facility. It is a tedious task that rewards dedication.

And that, Graham says, is why he welcomes being quizzed.

"I do it for a reason," Graham said. "It's a challenge to get them to study."

He recalls an exchange with former Patriots edge rusher Chandler Jones from his time in New England, a moment that proved to Graham his method was working. Jones was eating in the cafeteria on a Tuesday, the players' day off, when Graham came over to say hello.

Jones cut him off instead.

"I know you're about to tell me about the sack in 2012," Graham recalled Jones saying. "It's the same guy (I'm facing this week), he's working here at Tennessee now, the one where I hit him with this move."

Graham raised his eyebrows. He was impressed with Jones' recall.

"Chan's gigabytes are up there," Graham said. "His gigabytes are real."

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The next step, according to Baker and Gray, would be for teams to incorporate specific exercises to train anticipation, decision-making and recognition the same way they train physical skills like tackling in football, shooting in basketball and bunting in baseball.

In this regard, both men said North American sports lag behind the rest of the world.

Baker, who spent a week with the Football Association in England earlier this year, said soccer programs are utilizing these training methods early as the pre-academy level, with young children, and sharpening those traits long before adulthood. Gray, who works primarily in baseball, said certain teams are starting to use video-based training systems for pitch recognition. Batters are instructed to watch a pitcher's delivery on their iPad and then, when the pitch is occluded, predict whether they saw a curveball or a fastball, a strike or a ball.

There is even a YouTube video for viewers to test their anticipation of tennis forehands.

"I think it's getting there," Gray said. "But I don't think everyone has fully bought into it yet."

From a football standpoint, the implementation of this technology remains inconsistent. Gray noted a company called STRIVR that has brought virtual-reality training to team sports in the United States, though the company's products also have more general applications. STRIVR has been popularized by the Stanford University football team in recent years, and its client list now includes seven NFL teams (Jets, Cardinals, Cowboys, Vikings, 49ers, Bears, Steelers), nine college football programs (Dartmouth, Baylor, Virginia, Clemson, Rice, Texas Tech, Auburn, Vanderbilt, Stanford), two NHL franchises (Capitals, Blackhawks) and two NBA organizations (Wizards, Pistons).

There also is a company called Axon Sports that has created cognitive training apps for athletes in basketball, football, baseball, soccer and rugby, among others, and its website promises customers will "improve the accuracy and speed of decision-making — get virtual repetition in the digital world at a scale impossible to achieve in the physical world." The company's list of partners and clients includes the Pro Football Hall of Fame, which two years ago incorporated Axon into its three-day Academy training program for young athletes. Classroom sessions using Axon's products will "help athletes improve their reaction and decision-making ability," according to a news release issued at the time.

"I think there's a lot more room for those kinds of things," Gray said. "I'm a really big believer in developing sport-specific things."

Across the Packers' locker room, players had little experience with these types of methods and were largely unfamiliar with the science behind training anticipation or advanced cues.

This is where Baker said he would make an adjustment to the way players are evaluated prior to the NFL Draft each year. His goal as a fictitious member of the front office would be to explain that many of the skills associated with common questions at the annual scouting combine — Is this player a good decision-maker? Is this player capable of understanding formations and alignments? Can this quarterback read defenses? — can actually be developed once that player is part of an organization, whereas things like height, arm length and the ability to put on weight aren't trainable at all.

Which is why, according to Baker, teams should be designing specific exercises identifying the important advanced cues associated with each position on the field.

“So if I was working in the front office, I would be putting someone on, well, what exactly (is it) that a running back needs to be able to pick up faster than other teams’ running backs so they’re in the right place at the right time?” Baker said. “Or what’s the kind of posture that the defender is reading so that we can start to develop fakes … and give our running back more space? Those are the kinds of things that I think are critical, and we’re starting to see the evidence pile up. But I don’t know if that many teams are actually learning to exploit those as much as they could.

“We need to be thinking about a new player who is drafted into the league on Day 1. Yeah we’ll give them a physical-conditioning program, we’ll give them the game book with all of our plays and stuff. But we also need to develop a strategy for training anticipation and decision-making skills that parallels the development of physical skills. Because those are the types of things that we’re relying on emerging naturally through experience and through training and scrimmage, but we can train them so that they emerge faster.”

For Baker and Gray, their closing argument could be a short video depicting 10-time baseball All-Star Albert Pujols — winner of three Most Valuable Player awards, owner of more than 3,000 career hits and exactly 633 home runs — facing off against Jennie Finch, an Olympic gold medalist and one of the greatest softball pitchers of all time. Pujols takes the first pitch high for a ball before swinging and missing at the second. He flails wildly at the third and comes nowhere close to the fourth. An easy strikeout for Finch.

How can someone as talented as Pujols, a surefire Hall of Famer, look so foolish against underhand pitches … from a short distance … featuring a ball significantly larger than ones he’s launched over outfield fences his entire career? It’s a question raised by Epstein in the first chapter of his book, and the answer validates Graham’s pursuit of football-specific “gigabytes” with the Packers.

“Even skills that appear to be purely instinctive — jumping to rebound a basketball after a missed shot — are grounded in learned perceptual expertise and a database of knowledge on how subtle shifts of a shooter’s body will alter the trajectory of the ball,” Epstein wrote.

“It’s a database that can be built only through rigorous practice. … Without that database, every athlete is a chess master facing a random board, or Albert Pujols facing Jennie Finch, stripped of the information that allows him to predict the future.”

In other words, Pujols had the wrong set of gigabytes.