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HUMAN FACTORS GOES

ARMCHAIR QUARTERBACKS don't usually have to prove themselves, but we did. We made the mistake of saying to a college football coach that we couldn't understand how quarterbacks could make so many wrong decisions when choosing their receiver. We assumed that after long hours of practice and years of experience, quarterbacks would have highly developed skills in recognizing the open receiver.

A long and painful educational process followed. The coach explained that quarterbacks have few opportunities to train on the visual task that faces them each week during the game. We had assumed that each quarterback had thousands of training trials; the

unique application of a computer

coach pointed out that there were at most a few hundred hours of practice, only a small percentage of which were spent practicing with full offensive and defensive teams.

Given that this practice time is distributed over hundreds of different offensive plays and defensive set combinations, and that a team is trying to train three or four quarterbacks at a time, a college or professional quarterback actually has few repetitions (or no practice at all) with a specific scenario before the play occurs in a game. We learned that given the complexity of the visual stimuli, extreme time pressures, and external stressors (think of those blitzing linebackers!), it is surprising that they select the correct receiver as often as they do.

Why don't quarterbacks have more training time? Primarily because of the number of personnel hours required for a full scrimmage. We made the further mistake of pointing out the similarities between our work in human factors and the challenges facing a quarterback coach. In many ways, training quarterbacks presents a classic training problem faced by human factors professionals. Developing passing skills is similar to the challenge of training air traffic controllers, pilots, and operators of command and con-

TO THE GRIDIRON

BY NEFF WALKER & ARTHUR D. FISK

trol systems in the military. By the time the discussions were over, we had committed ourselves to developing a simulation-based training system for quarterbacks.

Task Analysis of a Quarterback's Job

Our first step in designing a training system for quarterbacks was to specify precisely the skills that our system would develop. We worked with a coach of the University of Maine football team to carry out a task analysis of the quarterback's job.

The task analysis identified four primary cognitive and perceptual processes that a

-based video training system.

quarterback must perform. First, given a play, the quarterback must remember the pass pattern that each of the receivers is expected to run. Next, as the quarterback leaves the huddle and goes to the line of scrimmage, he must visually scan the defense and determine what defensive set he is facing. This is a dynamic process, as the opposing team will shift positions in an attempt to hide the defensive set they will run when the play begins.

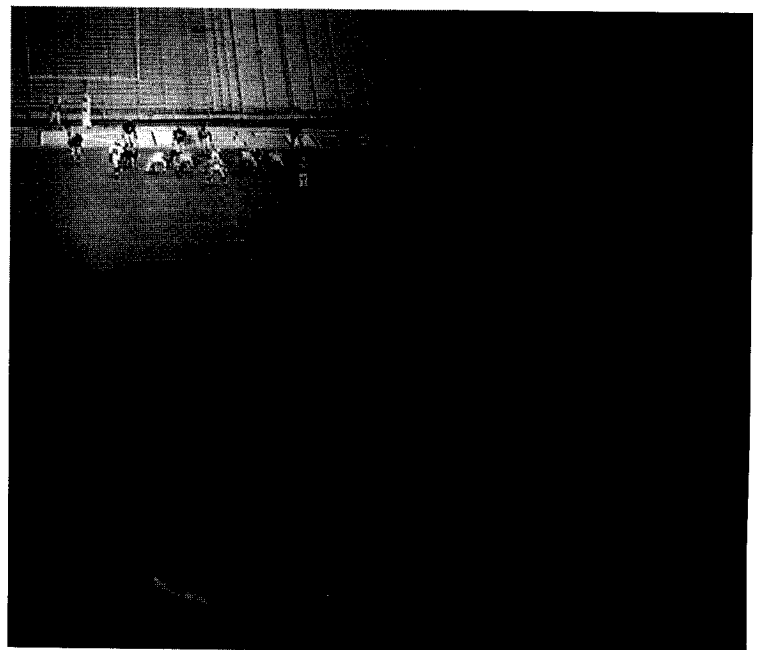
Based on the quarterback's decision about the defensive set, he must remember a "read sequence" for the receivers. This sequence is specified in advance and directs the quarterback's visual search. In other words, he is supposed to remember, given this play and defensive set, that he should first look at one receiver, then a second, a third, and so on, in a specified order. Finally, once the ball is snapped, the quarterback must then look at each of these receivers, determine which one is "open," and then throw the ball to that receiver.

We then categorized this straightforward list of tasks into two major types: retrieval tasks (remembering the pass patterns and receiver read sequences) and perceptual judgment tasks (recognizing the

defensive set and making a judgment about which receiver is open). Both types of subtasks would need to be addressed by the training system.

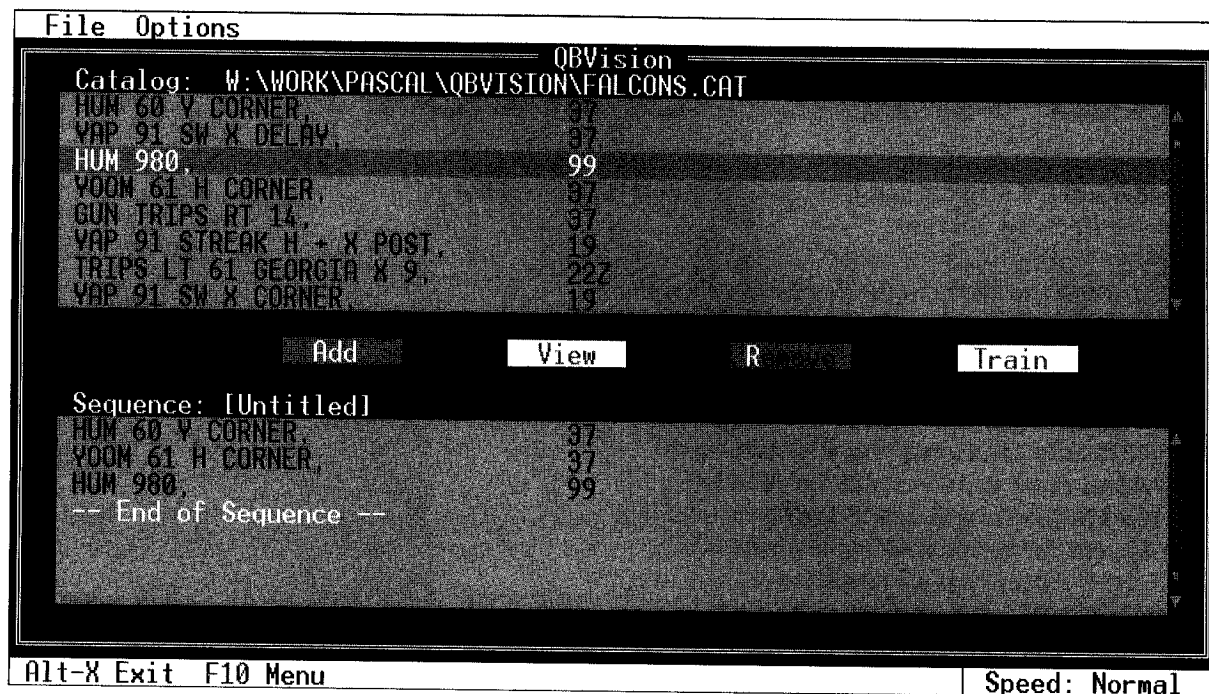
We also realized that there are many other factors affecting a quarterback's performance. For example, the quarterback must use time management skills – watching the clock and making the most effective use of time. In addition, "situation awareness" comes into play in the decision-making process. For example, on a third down and short-yardage play, the quarterback should choose a safe pass that gains the necessary yardage rather than trying to pass to a receiver farther down the field. On the other hand, if it is second down and one yard to go, the quarterback should throw to the deep receiver. The quarterback must also be able to change plays at the line of scrimmage ("call an audible").

Although all of these tasks are important in a quarterback's performance, the improvement of these skills was not the primary goal of our training system. We believed that performance on the field could be significantly improved through training that



An example of the large-scale display used for training quarterback visual recognition skills.

The system interface used by the coach to build a training sequence of plays.



focused on information retrieval and perceptual judgment tasks. Based on our analysis of the tasks facing a quarterback and on previous research (Fisk and Eggemeier, 1988; Kirlik, Walker, and Fisk, in press), it became clear that the following were keys to effective training:

1. identification of consistently trainable components,
2. effective part-task training,
3. a high number of repetitions and immediate and appropriate feedback,
4. development of automaticity,
5. task composition (putting the individual skills together), and
6. targeting of skill deficiencies for focused remedial training.

The Training System

Our system is a laser-disc-based simulation that has the capacity to store more than 300 plays per disk and allows rapid random access to any play. Combined with a projection system, the laser disc player can present a 3 ft × 5 ft (1 m × 1.5 m) or larger view of a football field as seen from behind the quarterback. We used videotapes taken from the end zone using a wide-angle lens, which were edited and transferred to the laser disc medium. Each lasts approximately 6 to 8 s and presents the quarterback a view of all the offensive and

defensive players on the field from the time the players break out of the huddle until the play ends. Presentation of the plays is controlled by means of a 10-button control panel similar in size and shape to a computer keyboard. Eight of the buttons represent possible receivers. (Obviously, there are not eight eligible receivers, but this setup allowed us to spatially represent receivers from all possible offensive sets.)

The first press of a button displays the name of the offensive play. The second press initiates the visual projection of the play and starts a timer. The presentation continues until either the quarterback presses a button indicating his choice of receiver or the play comes to its natural end. If a receiver is selected, this button press is accompanied by one of two auditory tones indicating a correct ("beep") or incorrect ("buzz") choice. Additional feedback on the accuracy of the choice of receiver and the time required to make the decision is displayed.

The computer also displays information that the coach has entered into the computer file describing the visual cues (e.g., the defensive set, the read sequence) that should allow the quarterback to choose the correct receiver. The player can then press a button to continue the same sequence with a new play or can press another button to repeat the play just shown. In all cases, the infor-

In many ways, training quarterbacks presents a classic training problem faced by human factors professionals.

mation displayed by the computer is simultaneously displayed on the screen and the projection system. Therefore, when a player is using the system to train, he need never look at the computer screen. All information about upcoming plays and feedback is overlaid on the visual display of the laser disc.

The system is controlled by a set of programs written in Visual BASIC. A fundamental component of the computer programs is a catalog file that contains all information about each play stored on the laser disc. The location of each play is indexed, indicating to the program where to start and stop the display. Other information stored for each play includes the name of the defensive set, the receiver read sequence, the correct receiver choice, and the coach's hints about what the quarterback should be looking for.

The information in this catalog file is entered into the program one time in the form of a text file for all plays on the disk. A second program allows the coach to create "sequence or training" files to be used in individualized training of quarterbacks. The coach can set a listing of all plays and the corresponding defensive sets that are recorded in the catalog file. He can then scroll through the catalog file and use the mouse or keyboard to select plays to become part of new sequence files.

The plays selected for a particular sequence file can be previewed by the coach during the selection process. Plays within a file can also be presented either in the order that they appear in the file or randomly. The coach can vary the speed of presentation of the plays. Once a file has been created, it is stored and becomes available for the coach to use in training or to select as the basis for creating a new sequence file.

The coach can also select the type of training that the player will receive: part task or whole task. Two part-task training sequences can be selected. First, the coach can choose to have the player practice retrieving the correct read sequence. For this task, the player is given the play and defensive set in text on the computer screen and must respond by pressing the receiver keys in sequence on the input board.

A second part-task training task shows the player the defensive set via the projection screen; he must respond with the correct defensive set. Again, the quarterback

responds via the input board and receives feedback on the speed and accuracy of his response. As with the full-task trainer, the player can elect to review the same defensive set immediately by pressing the appropriate button on the input board.

If the coach selects whole-task training, the play is named on the computer screen, and the quarterback then presses a button on the input board to start the projection. The quarterback watches the play and presses the button to select the correct receiver. In this program, the play stops only when the player picks the correct receiver or the play ends. As with the part-task training, feedback is provided to the player in the form of an auditory signal and through speed and accuracy results, as well as the coach's hints, displayed on the computer screen. The player can then choose to go to the next play or to repeat the play he has just seen.

For all of these programs, summary feedback is given to the player at the end of the training sequence, including average response speed and accuracy. This information is stored in a file so that it can be reviewed by the coach at a later time.

The third program, used by the player, presents the sequence file(s) that the coach has created and allows the player to review past performance. The system is designed so that all commands (except starting the program) can be initiated through button presses on the input board.

The task analysis identified four primary cognitive and perceptual processes that a quarterback must perform.



Using the System

Our assumption was that the system would be used primarily for off-season training. We believed that with extensive practice on the part- and whole-task sequences, the quarterback could develop automaticity in both the subcomponent skills and in the whole task.

With this in mind, we shot videotape of the Georgia Tech football team during spring training. By the time the tape had been processed and edited and associated information for each play entered in collaboration with the coaches, it was too late to use the system for off-season training; instead, it was introduced during the fall season. We should also note that a new offensive coordinator joined the team in the spring of 1994 and introduced a new passing offense. This meant that none of the

quarterbacks to be trained had extensive experience with the offense.

The system was set up in the quarterback coach's training room, where he holds meetings with the quarterbacks. The equipment included an IBM-compatible micro-computer, a laser disc player, a video scan converter, and the input board, all of which were placed on a rolling cart that could easily be moved around the room. The laser disc player was connected to a projector and displayed on a projection screen.

During teaching sessions, the three to four quarterbacks would sit facing the screen with the coach beside them and the computer equipment on the rolling cart immediately to their left. This allowed all players to look directly at the projection screen from the perspective of the quarterback while the play was being displayed. The name of the play was displayed, and the coach reminded the quarterback of what the key reads were going to be in choosing the correct receiver. Then he allowed the play to run and each quarterback to make his decision. After each play, the quarterbacks and the coach discussed the reasons for a particular decision, often reviewing a play many times.

This use of the system by the Georgia Tech coach differed in important ways from what we had anticipated. Although we had designed the system with independent learning in mind (the quarterback would use the system alone and have the results reviewed by the coach at a later time), the Georgia Tech coach used the system as an interactive teaching tool. He sat down with the players and went through the plays one at a time.

Another innovation introduced by the coaches was the use of a device called "Coaches' Assistant." This is a commercial system that permits drawing directly on the projected display, allowing the coach to highlight key features (e.g., a linebacker blitzing, dropping into double coverage) that the quarterback should have noticed when choosing a receiver. Based on this usage, we updated the program so that it now allows the user to draw on the display with the mouse connected to the computer.

The coaches also learned very quickly that the system could be tailored to meet specific learning objectives, as shown in the following examples. First, the coaches created sequence files for specific types of situ-

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ations that occurred during the games. This use of special sequence files allowed the player to be trained intensively in a particular problem area. For example, the coaches created a sequence file for goal line situations that included plays used in these circumstances. Second, because coaches often script a set of plays that will be used in the opening drives, these plays were placed in a sequence file. The player would go through this file during the week of and the hours immediately prior to the game.

Team Response to the System

The response to the system by both the coach and the quarterbacks was overwhelmingly positive (see *Sports Illustrated*, September 6, 1994). Both coaches and quarterbacks were enthusiastic about two features. First, they emphasized the importance of the visual perspective of the videotape. Although reviewing videotapes or game films is a common teaching technique among football coaches, few teams shoot videotape from a wide, end-zone perspective, from which the quarterback can see all of the players on the field. This perspective provides a view that is similar to what the quarterback actually sees during play, and this added realism was reported to make teaching and learning more effective.

A second critical feature praised by the coach and quarterbacks was the active learning process that it promoted. During the training and review sessions, the player was required to make a response, rather than simply watch the films passively, as is normally the case. The quarterback coach was particularly enthusiastic, saying that one of the problems in the usual approach to training using videotape is that it is difficult to involve the player.

In addition to these features, players also reported that although they appreciated the interactive use of the system, they were glad that it also permitted them to practice independently. One quarterback emphasized the importance of repetitions in mastering these skills, noting that it was a much less painful way to learn, compared with dodging linemen during practice.

Planned Extensions

On the basis of the first six months of use, we identified a number of ways in


which the quarterback training system might be expanded and improved. The quality of the video should be improved and the perspective moved farther up the field to immediately behind the quarterback. From discussions with representatives of the Sony corporation, we learned that this is technically feasible, though the equipment is expensive. Using current technology, we would be able to videotape the play from approximately 17 yards behind the line of scrimmage.

We are planning to switch from laser-based storage to CD-ROM storage. Initially we avoided this approach because of limitations of the storage capacity and visual resolution of CD-ROMs. However, it seems that with new compression approaches (e.g., fractal compression), CD-ROMs will be able to store up to two hours of videotape without loss of display quality.

The rate at which perceptual judgment skills are acquired might also be increased through various training techniques. Two of these are the use of visual enhancements and changing the rate of play presentation. Visual enhancement refers to adding supplementary visual cues to the displays in the training of perceptual judgments. In this case, it might mean adding color overlays to specific visual cues that are necessary for the quarterback to make the correct decision: for example, highlighting a linebacker who is blitzing or dropping back into coverage, or a secondary who drops back into a zone. This could be done by using a video "toaster" – a piece of equipment that allows the user to add color overlays to an area or person on the display.

For the past three years, we and our colleagues have been investigating the use of visual enhancements in training through football simulations and other tasks that are dependent on visual judgments (e.g., Kirlik, Walker, and Fisk, in press; Walker, Fisk, Phipps, and Kirlik, 1994). We believe that this technique could be used to increase the rate of acquisition and to promote the transfer of skills to actual game situations.

Increasing or decreasing the rate of play presentation might also increase the rate of acquisition. This feature, though available to Georgia Tech coaches, was not used, and therefore it is not possible to evaluate its potential. One possible benefit is that when a quarterback is learning the system, a



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slower rate of presentation might aid initial acquisition. Later trials could be at normal and even higher-than-normal rates of presentation. We are currently conducting research to investigate this issue.

At the beginning of May 1995, Trek Sports (the company now producing the system) delivered a modified version of the system to the Atlanta Falcons. The Falcons provide us with an interesting second test case, as their passing offense is very complex (a variant of the run and shoot), especially in its demands on the quarterback. The Falcons team is using the system during its spring minicamp. We have scheduled meetings with the coaches and players and will conduct a set of structured interviews that will allow us to determine the impressions of coaches and players about system effectiveness, aspects of the system that they deem critical for performance improvements for players across a range of abilities, the ways the system was used, and the modifications they would like to see implemented. We will also discuss with the coaches ways in which the system could be used to train players for other skill positions.

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Neff Walker is an assistant professor of engineering psychology at the Georgia Institute of Technology, School of Psychology, Atlanta, GA 30332-0170. Arthur D. Fisk is professor and head of the Engineering Psychology program at Georgia Tech. The authors would like to thank Mark Johnson, Scott Walker, and the people at Trek Sports for their help. ■