The Matrix Decoded

Teacher Information

Background Information

Have you ever noticed that when you really think about what you are reading, your lips sometimes move and you silently "speak" the words? There's a reason for that. The brain sends out signals that connect what we think and what we say. We usually don't "read along with our lips" because it slows us down when we read. Still, it is a natural connection. Researchers at NASA are learning how that thought-speech connection can be used to help us communicate even better.

To make this technology work, researchers place electrodes on the larynx of the user. The electrodes record sound signals. The device doesn't record words, though, it records sounds. And each sound is assigned a pair of numbers. Researchers use numbers to code the alphabet into a matrix. For example 1,1 is used to record the letter a. The letter b is shown as 1,2 and so on. This coding is used because subvocal speech technology doesn't recognize the alphabet. In a test, NASA researchers used the new technology to control a small Mars rover. They were able to direct the rover to different locations without any audible sounds. Commands for the rover were thought, but not spoken. Using the new technology, the rover moved in the correct direction.

In this lesson, students will learn how the researchers use a matrix to assign numbers to each sound. They will then use this code to decode a series of words and sayings.

Key Concepts and Student Information

- Matrix – a table of intersecting rows and columns
- Subvocal speech – communicating without actually talking

Materials

NASAexplores 5-8 article, "Do You Hear What I'm Saying?" (1 copy per student)
Student Sheets (1 copy per student)

Procedure

1. Read the NASAexplores 5-8 article, "Do You Hear What I'm Saying?" Discuss.
2. Revisit the paragraph that discusses how researchers use a matrix to assign number pairs to different letters of the alphabet.
3. Explain that a matrix is a grid of intersecting rows and columns. Distribute the Student Sheets to give students an example. Be sure to point out that letter a is represented by the pair 1,1 just like in the article.
4. Go over Student Sheet instructions. Answer questions before students begin.

Enrichment Activities

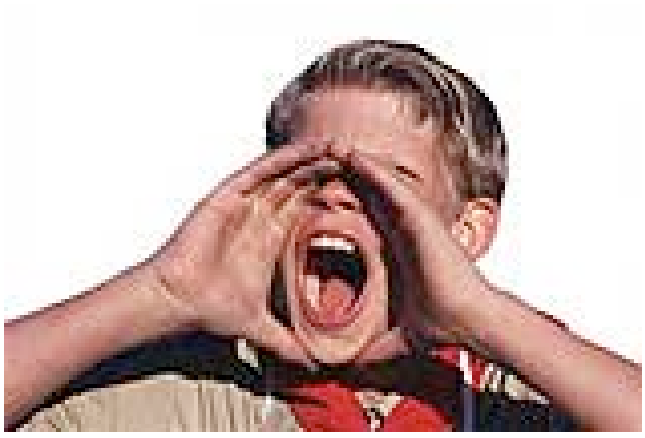
- Discuss other uses for the matrix coding system.
- Have students come up with their own puzzles to be decoded.
- Discuss possible uses for subvocal speech technology.

Answer to Student Sheet Message: In the future, subvocal technology could be used by SCUBA divers to speak to each other while under water.

Do You Hear What I'm Saying?
NASAexplores article, August 25, 2004
http://www.nasaexplores.com/show2_articlea.php?id=04-056

Have you ever noticed that when you concentrate on what you're reading, your lips sometimes move and silently speak the words? There's a reason for that. The brain sends out electrical signals that connect thinking and speech. We often avoid "reading with our lips" because it slows down the process, but it's a natural connection. Researchers at NASA are learning how that thought-speech connection can be used for better communication.

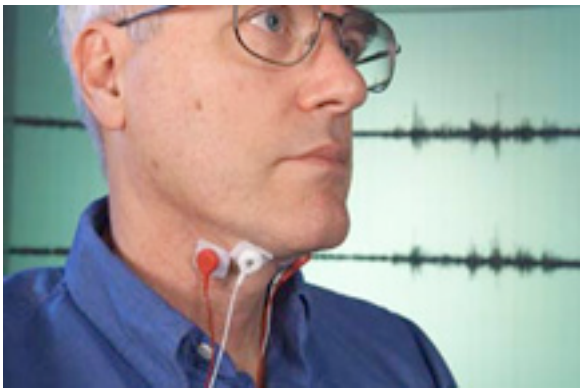
Imagine being able to speak to someone without ever making a sound. That's the idea behind the subvocal speech project at NASA's Ames Research Center. Researchers have found that when people think of something to say, the brain sends out faint electrical signals with that same message—even if the person never speaks the words out loud. When researchers magnify those electrical signals and translate them into real words, people can think a message and the message will be turned into words. This is a form of voice recognition. It sends a message while cutting out the breath and sound vibration parts of speech. This technology is called subvocal speech. Subvocal means "below the spoken voice," referring to the nerve signals to the muscles that we use when we produce sounds.



Yelling is one way of sending a message to others. Why would it be useful to speak without using your voice? "People working in high-noise areas, such as construction sites or airports, could use subvocal communication to send commands and instruction for tasks when they otherwise couldn't be heard," says Chuck Jorgensen, chief scientist for neuroengineering at NASA Ames. "People who have suffered damage to their vocal cords could communicate by thinking, rather than speaking, their thoughts. Space explorers who may get injured while on Mars could use subvocal speech to call for help. And when sitting in a crowded room, people could ask each other a private question without bothering the rest of the people." Passwords could be entered without anyone else hearing the word. Deep sea divers could communicate to diving partners in an environment where words are impossible. Telephone calls could be conducted silently.

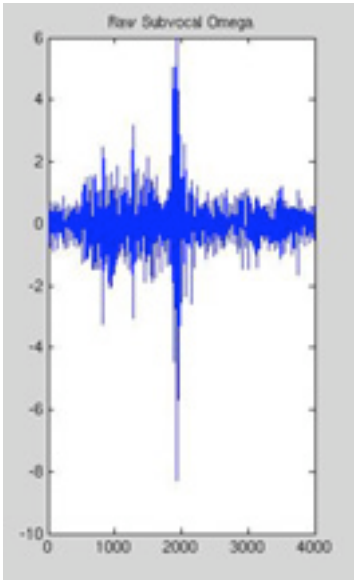
Do You Hear What I'm Saying? (Continued)

Don't get the wrong idea about subvocal speech, though. It's not mind reading. It's just like typing a word on a computer keyboard, but the message is sent by thinking the idea rather than by typing the words. Subvocal speech is totally voluntary; nobody forces anyone to think on demand.



To make this technology work, small electrodes are placed on the throat near the larynx. The signal that is created by thinking is captured and recorded. The list of recorded nerve patterns creates a type of dictionary that a computer remembers. So far, the system is able to recognize a few words, and only words spoken by a particular voice. As the system improves, it will be able to recognize more words and more speech patterns.

Researchers use numbers to code the alphabet into a matrix, so that 1,1 is the letter a, and 1,2 is b, and so on. They do this because subvocal speech technology cannot yet recognize the alphabet. In a demonstration, NASA researchers were able to control a small Mars rover by directing the rover without any audible sound to go to different locations. Commands such as right and left were thought, but not spoken, and the rover responded.



Everyone's voice creates a unique pattern.The electronic "signature" put out by your muscles is unique, just like fingerprints, Jorgensen says. Identifying the various signals that translate into different sounds and words is the challenge the researchers face now. Not only is every word different, but each person pronounces those words a bit differently, too. Regional accents and individual pronunciation create big differences in the signal.

Because English has so many different ways to pronounce the same letters, the researchers decided to use Latin when they first experimented with subvocal speech. English has diphthongs—combinations of vowels that create unique sounds, such as the word "voice"—and depending on how the letters are arranged, letters can have several different pronunciations. "Nasal languages, such as English and French, turned out to be much harder to develop into subvocal speech," says Jorgensen. "Languages with hard, guttural sounds, like German and Japanese, are easier. They are more consistent in how each letter is pronounced. And, Latin was the easiest tool for pulling out sounds and making consistent pronunciation. So, there's one more reason to know another language!"

The Matrix Decoded

Student Sheets

Objective
To understand how to decode a message using a matrix.

Materials
Matrix Decoded Worksheet
Do You Hear What I'm Saying article

Procedure
1. Read the "Do You Hear What I'm Saying?" article from NASAexplores.
2. Practice identifying letters using the matrix code on the *Matrix Decoded* student worksheet
3. When you have finished the Decoding Practice and Coding Practice, go on to decode the message on worksheet #2.
4. After decoding the message, create a message of your own, and code it according to the matrix.
5. Have someone else in your group decode your message.

The Matrix Decoded

Student Worksheet

Subvocal speech technology cannot recognize the alphabet yet, so researchers use numbers to code the alphabet into a matrix, so that (1,1) is the letter A, and (1,2) is B, and so on.

The box below is called a matrix; it is a grid with intersecting rows and columns. Researchers at NASA use a matrix, like the one below, to assign a letter to a pair of numbers. For example, the pair of numbers (3,2) is found on the matrix by finding the number 3 in the top row and seeing where it intersects with the row containing the number two in the left vertical column.

	1	**2**	**3**	**4**	**5**
1	A	B	C	D	E
2	F	G	H	I	J
3	K	L	M	N	O
4	P	Q	R	S	T
5	U	V	W	X	Y
6	Z				

In the matrix above the horizontal and vertical rows intersect at the letter H. Therefore, whenever the pair of numbers (3,2) is seen, the computer will interpret the code as the letter H. Some other examples are:

(4,4) = S
(1,5) = U

DECODING PRACTICE:

(2, 4) = _____ (5, 3) = _____ (3, 5) = _____

You can also use the matrix backward to create your own secret message! In order to do this first, create your own secret message. Then, for each letter in the message find the corresponding pair of numbers. For example, if your message you wanted code is the word NASA, then your secret code would be:

NASA = (4,3) (1,1) (4,4) (1,1)

CODING PRACTICE:

R = (____, ____) C = (____, ____) I = (____, ____)

Student Worksheet #2

Try out your new decoding skills, use this matrix to decode the secret messages below.

	1	2	3	4	5
1	A	B	C	D	E
2	F	G	H	I	J
3	K	L	M	N	O
4	P	Q	R	S	T
5	U	V	W	X	Y
6	Z				

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___,
(4,2) (4,3) (5,4) (3,2) (5,1) (1,2) (1,5) (5,4) (1,5) (3,4) (5,1)

(4,4) (1,5) (2,1) (2,5) (5,3) (3,1) (1,1) (2,3) (5,4) (5,1) (3,1) (3,2) (4,3) (5,3) (2,3) (5,3) (2,2) (5,5)

(3,1) (5,3) (1,5) (2,3) (4,1) (2,1) (5,1) (1,5) (4,4) (5,1) (4,1) (2,1) (5,5)

(4,4) (3,1) (1,5) (2,1) (1,1) (4,1) (4,2) (2,5) (5,1) (3,4) (4,4) (5,4) (5,3)

(4,4) (1,4) (5,1) (1,1) (1,3) (5,4) (5,3) (5,1) (1,1) (3,1) (3,2) (5,3) (5,4) (3,2) (5,1) (3,4)

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___.
(3,5) (3,2) (4,2) (2,3) (5,1) (1,5) (4,3) (4,1) (5,1) (3,4) (3,5) (1,1) (5,4) (5,1) (3,4)

<u>Use the space below to write out your own short secret message</u>

____

Now, using the matrix above code your secret message into pairs of numbers.