ASTER JOURNAL OF NEUROSCIENCES

Aster Publications Review ISSN:

Thinking Outside of the Speech Box: Cranial Nerves Made Simple

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Received: Jan 26, 2017; Accepted: Apr 22, 2017; Published: Apr 25, 2017

Competing interests: The author has declared that no competing interests exist.

Cite as: Hannibal RR. Thinking Outside of the Speech Box: Cranial Nerves Made Simple. Aster J Neurosci. 2017; 1: 1-11.

ABSTRACT

Cranial nerves provide sensory and motor innervation to numerous structures that are important for speech, phonation, resonance, and swallowing. They also supply innervation to voluntary and involuntary muscles. An understanding of the cranial nerves is essential to the practice of speech-language pathology because they provide valuable information to the function regarding speech, voice, and swallowing abilities. Since speech language pathologists work with individuals with neurogenic cognitive-communicative and swallowing problems, it is imperative to know how these nerves are affected anytime there is a brainstem lesion or a neurologic impairment. Further, it is important that speech language pathologists have a working knowledge of the function of the cranial nerves and their significance as a dynamic and powerful tool that is used in the diagnosis of speech and swallowing disorders. The purpose of this article is to provide the reader with a brief overview of the cranial nerves, how to apply simple everyday actions to learning them, and how to perform a cranial nerve examination as an essential component of any speech, voice, and swallowing examination.

Key Words: Cranial nerves , Personally relevant, Assessment, Brainstem

INTRODUCTION

Throughout the years of teaching numerous classes in communication sciences and disorders, one aspect of teaching that students often do not grasp as readily as other concepts is the importance of cranial nerve examinations. They often memorize the information but do not seem to understand the purpose of application to clinical practice. Studying the cranial nerves can be quiet overwhelming to many students. It is not the intent of this article to provide a detailed view of the cranial nerves but rather to provide a simple way of understanding and learning the cranial nerves, how to perform a cranial nerve examination and how to apply knowledge of them to everyday and clinical practice. Wallace and Canter [1] cited how important it was to incorporate personally relevant information into therapy for persons with aphasia. The same philosophy holds true when learning the cranial nerves. It is easier when one is able to make the knowledge of the nerves come alive by applying them to everyday life and by making them personally relevant.

The brain is connected to parts of the head and neck by 12 pairs of cranial nerves [2].These cranial nerves are essential for many things that we do on a daily basis. In order to get students excited about learning them, there are several ways that have been suggested as easy ways to learn the cranial nerves. One way is to apply an acronym or a mnemonic such as OOO for olfactory, optic, oculomotor or the mnemonic, On Old Olympus Towering Top, A Fin and German View Some Hops [3]. While that is one way, another way that students are introduced to the cranial nerves in class is to make up a story that brings the cranial nerves to life. An example of such a story goes something like this: As I step off the escalator from the train at Chicago O'Hare, I immediately smell (olfactory) the Cinnabons in the food court. I turn to my left and find the kiosk. (Optic and accessory). I peer into the sea of Cinnabons (optic) and look left and right, up and down (oculomotor, trochlear, abducens) until I find the ones with the pecans. Once I find the one that I want, I indicate to the cashier that I want the gooey one with the pecans. I pay for my Cinnabons and go to my concourse. When I arrive at my concourse, I sit down to eat my sweet treat. My mouth opens to receive the treat (Trigeminal); I bite down into it and start to chew (Trigeminal, Facial). As I am chewing, I taste the wonderful flavor of the Cinnabon and shape the food into a cohesive bolus (Facial, Glossopharyngeal and Hypoglossal). As I prepare to swallow my first bite (trigeminal, facial, glossopharyngeal, vagus), I turned my head around (Accessory) as I look at the person (optic) at the Delta counter as I hear (Vestibulcochlear) the announcement that it is time to start boarding the plane. I smile (Facial) as I finish eating my Cinnabon (Vagus).

As the students learn the cranial nerves, make learning them fun by using examples that are personally relevant to everyday activities. As students sit in class listening to a lecture, many times they are required to apply the nerves to what they are currently doing.

Teaching tips: *As the students begin to learn the cranial nerves, provide examples to the class and also ask them to provide examples on how they can remember the different cranial nerves. For instance, when I smell perfume, baked goods, or coffee brewing, I am using my olfactory nerve (I). When I watch a tennis match, I am using my optic (II), oculomotor (III), trochlear (IV), abducens (VI), and accessory nerve (XI). When the players grunt each time they hit a*

ball, I hear their grunts (Vestibulcochlear, VIII). When I lick a tootsie pop, I am using my hypoglossal nerve (XII). As I sit in my chair I am reading the PowerPoint (optic, oculomotor, trochlear, abducens), I listen to the professor's lecture (Vestibulcochlear). Someone asks a question, I turn my head to see who it is (Accessory). I have been in class for 40 minutes and I am thirsty. I take a drink of my water (Trigeminal, facial, glossopharyngeal, vagus, spinal accessory, hypoglossal).

The cranial nerves supply function to the muscles of the face, eye, palate, pharynx, larynx, tongue, glands, and neck, and also include innervation to voluntary and involuntary muscles [4]. Some cranial nerves serve specific sensory function, some motor function, and some serve mixed function [3,5]. They are numbered by Roman numerals I through XII for which they are sequenced and how they exit/and enter the brain.

The first two cranial nerves, Olfactory (CN I) and Optic (CN II) originate in the cerebral cortex. Specifically, the olfactory nerve originates in the telencephalon of the cerebral cortex. The optic nerve originates in the diencephalon. Cranial nerves III and IV originate in the mesencephalon (midbrain). Cranial nerves V-VIII are located in the pons, and cranial nerves IX-XII are located in the medulla oblongata of the brainstem [3]. There are seven functional types of cranial nerves. They are classified as following: Sensory: General visceral afferent (GVA), Special somatic afferent (SSA), Special visceral afferent (SVA) and General Somatic Afferent (GSA) The motor types are General somatic efferent (GSE), General visceral efferent (GVE), and special visceral efferent (SVE) or Branchial efferent (BE). These classifications are important to SLPs because of their significance to some of the structures involve in speech, voice, and swallowing. For instance, special visceral/branchial efferent are responsible for controlling the muscles of the face, larynx, pharynx, and neck. Some cranial nerves serve sensory functions such special somatic afferent, which are related to vision from the retina and for audition and equilibrium from the inner ear [3]. Not all of the 12 pairs of cranial nerves, however, are directly involved in speech, voice, or swallowing functions. It is still important, however to have a working knowledge of each one's importance when working with individuals who have neurologic impairments and their deleterious effects on the human nervous system.

The olfactory nerve (CN I) is the shortest of all 12 cranial nerves [6]. "It arises from the olfactory receptor nerves in the olfactory mucous membrane" [7, p. 333]. It is a sensory nerve that is responsible for smell. Often times the olfactory nerve is not assessed during a routine neurologic examination or during a swallowing examination. One may reconsider this practice especially when a person has sustained a traumatic brain injury or if the person is elderly. If there is damage to the olfactory system, the person will more than likely not be able to smell when there is smoke in a room, or any other toxic fumes that may be present. Additionally, it is important to assess 'smell' in the patient who is elderly. The reason for this is that they may not realize that food spoiled and also may not smell smoke in a room. Impairment in the ability to smell is called anosmia. The impairment may partially impair a person's ability to smell or it may fully impair a person's ability to smell. Impairment in the olfactory system can also be associated with hyposmia which is a decreased olfaction sensation and hyperosmia, which is an acute sense of smell [3].

Teaching tip: *Ask the student to smell a vial of coffee or smell lavender or peppermint and apply it to the function of olfactory nerve.*

Many of the stimulus SLPs provide to their patients are visual. Therefore, it is important that the cranial nerves associated with vision and eye movements are assessed. Assessing these cranial nerves is one of the first things that an SLP does as part of their overall physical assessment of the face of the patient as they enter the patient's room. The ability to see and the ability to move his/her eyes are important in reading and during visual confrontation naming. The optic nerves (CNII) arise from the retina. It is a sensory nerve that is responsible for vision. SLPs want to be sure that the patient is seeing the material that is been provided and that their eyes are moving from left to right in order to read the material.

Ocular movement is produced by the oculomotor, trochlear, and abducens nerves. Ocular movement is essential for reading and for all visual activity. Oculomotor (CN III), "emerges from the ventral surface of the midbrain medial to the pes pedunculi" [3, p. 85]. Trochlear (CN IV) is "located in the tegmentum of the midbrain at the level of the inferior colliculus" [8, p. 70]. The abducens nerves "emerge from the ventral aspect of the brain stem at the pontomedullary junction" [8, p. 106].

Teaching tip: *Ask student to read a passage from their book or from the PowerPoint and ask them to apply optic, oculomotor, trochlear, and abducens nerve to their demonstration.*

Injury to any part of the visual pathway or to the entire optic nerve can result in visual impairments in any of the visual fields. Injury to the oculomotor nerve can lead to ptosis (drooping of the eyelid). A lesion in the trochlear nerve can lead to impairment in downward gaze while impairment in the abducens nerves can lead to paralysis of the lateral rectus muscle of the eye which impairs a person's ability to rotate the eye outward. Injury to muscles and nerves that are responsible for eye movement can lead to other problems such as diplopia (double vision) and nystagmus , "abnormal involuntary oscillation of the eyes during movement" [9, p. 27].

The next section will provide an overview of the cranial nerves that are significant to speech and swallowing. The first is the trigeminal nerve. It is the largest of the cranial nerves [10]. The trigeminal nerve is essential to different aspects of speech, hearing, and swallowing. It is located in the pons of the brainstem. It is mixed cranial nerve, having both sensory and motor components. It has three major sensory divisions, ophthalmic (V1), maxillary (V2), and mandibular (V3). The ophthalmic division also has three branches, frontal nerve, lacrimal nerve, and nasociliary nerve. Neither of these branches will be discussed in this paper.

The two sensory branches of the trigeminal nerve that are significant to speech and swallowing functions are the maxillary branch and the mandibular branch [11]. The maxillary division is formed by a number of nerves: Zygomatic, infraorbital, superior alveolar and palatine nerves. The significance of the maxillary

division is that it carries sensory input, pain, from the upper teeth and upper gums, soft and hard palates, and mucosal membrane [3,8] The mandibular division is the largest of the three divisions [12]. This division supplies innervations to the following areas: the tongue, lower gum, lower lip, mouth, the buccal mucosa, anterior half of the pinna and external auditory meatus and external surface of the tympanic membrane [3,8,11]

Teaching tip: *Instruct the students to work in pairs. Each student will take turns being the clinician. With a wooden tip cotton applicator or a gloved finger instruct each person to tell their partner to close their eyes and touch their face where the clinician touches.*

The motor component of the trigeminal nerve innervates the muscles of mastication; temporalis, masseter, internal pterygoid and external pterygoid [13]. (See Teaching tip Box 1). The temporalis muscle elevates and retracts the mandible. The internal pterygoid muscle elevates the mandible while the masseter elevates, closes and protrudes the mandible. The external pterygoid depresses and protrudes the mandible toward the opposite side and regulates movement from left to right. These movements are important for chewing and very important to assess during a swallowing evaluation. Having a working knowledge of what is involved in swallowing helps the clinician make an informed decision as to what to treat.

Teaching tip:

Box 1	TIME
T	Temporalis
I	Internal pterygoid
M	Masseter
E	External pterygoid

Box 1: Acronym for muscles of mastication

Teaching tip: *Ask the student to bring some food to class. As they take a bite of their 'morsel' ask them to apply the muscles of mastication to their demonstration.*

One does not often think of the role the trigeminal nerve plays in hearing. The trigeminal nerve controls the tensor tympani that connects the wall of the middle ear to the malleus. It acts as a protective reflex against intense low frequency sounds from chewing and one's own voice [14].

The facial nerve is the next nerve of discussion. The facial nerve is a mixed cranial nerve having both sensory and motor components. The facial nerve (CN VII) "emerges from the brain stem at the lower border of the pons, crosses the subarachnoid space, and enters the internal acoustic meatus" [8 p. 119]. It is the major motor nerve for facial muscles and facial expression. Wilson-Pauwels et al. [8] further add that this nerve "compliments V3 of the trigeminal nerve by providing sensation from the wall of the external acoustic meatus and the external surface of the tympanic membrane" (p. 210). With reference to swallowing, the special sensory (afferent) fibers carry information from the

taste buds to the lateral border of anterior-two thirds of the tongue, and to the soft and hard palates. In reference to swallowing, the extracranial branch innervates the muscles necessary in speech production [14], such as the orbicularis oris, the risorius, the buccinators, and the platysma. The facial nerve also has a parasympathetic component that is responsible for the secretion of saliva by the submandibular and sublingual glands as well as parasympathetic to soft and hard palates. The production of saliva is important in moistening the oral cavity needed in speech and deglutition.

Injury to the facial nerve can lead to a number of deficits. Depending on the site of lesion, injury can cause paralysis of the face on the ipsilateral side (Bell's palsy), loss of taste from the anterior two thirds of the tongue, and excessive secretion from the glands Additionally, if there is injury to the efferents of the middle ear, it may cause paralysis of the stapedius muscle [3, p. 389].

Teaching tip: *Instruct the students to smile and then round their lips.*

The vestibulcochlear nerve (CN VIII) is a sensory nerve that carries two different special sensations; auditory for hearing and vestibular for balance. The vestibulcochlear nerve is "laterally attached to the brainstem at the junction of the pons and the medulla" [3, p. 389]. The vestibular branch is responsible for equilibrium and neck position. The auditory nerve is responsible for hearing. Injury to the vestibulcochlear nerve and their nuclei can lead to hearing problems such as conductive and sensorineural hearing loss. Damage to the vestibular branch can lead to balance problems.

The glossopharyngeal nerve (CN IX) is a mixed nerve having both sensory and motor components. It emerges from the medulla oblongata in the brain stem. It innervates the stylopharyngeus muscle that helps to elevate the larynx and the pharynx and larynx, necessary for swallowing [14]. It shares similar anatomy as the vagus (X) nerve. The sensory component is the touch receptors of the soft palate and tonsils [11]. Injury to the glossopharyngeal results in ipsilateral pharyngeal elevation during swallowing, loss of taste from the posterior tongue and excessive oral secretions because of poor control of the parotid glands

The vagus nerve (X) is a long wandering nerve that is a mixed cranial nerve with both sensory and motor innervation to the pharynx, palate, larynx, esophagus, and stomach [11]. It "originates from the medulla and has three main branches: pharyngeal, superior-laryngeal and recurrent laryngeal"[14, p. 82]. The vagus nerve is a complex nerve. With regards to voice, "the vocal folds are controlled by the intrinsic laryngeal muscles, which are innervated by the vagus nerve (X)" [14, p. 87]. The vagus nerve also has responsibility for such things as taste sensation from the pharyngeal area, gagging, coughing, swallowing, phonation, breathing, cardiac rate as well as vomiting. Injury to this nerve can lead to a number of deficits such as ipsilateral paresis of the soft palate, larynx, pharynx, voice problems, as well as swallowing.

Teaching tip: *Pair the students together. One will be the patient and one the clinician. With a penlight shining in the*

oral cavity and with a tongue blade, the clinician will touch the back of the patient's tongue and have the patient say "ah" at the same time.

The spinal accessory nerve (XI) is a motor nerve that is responsible for head and shoulder movement. It originates in the medulla. The spinal accessory nerve helps to tilt the head backwards and from side to side. It also is responsible for shrugging the shoulders. The significance of the spinal accessory nerve is it plays an important role in postural techniques in swallowing therapy.

Teaching tip: *Have the students perform the following postural techniques during the swallow: turn head to the left, turn head to the right, put chin to chest.*

The last cranial nerve to discuss is the hypoglossal nerve (XII). The hypoglossal nerve originates at the bottom of the medulla. It is a motor nerve that supplies all the intrinsic and all but one extrinsic muscles of the tongue, except for the palatoglossus muscle [8,15]. The hypoglossal nerve is important because it helps to shape the food into a cohesive bolus and also important for shaping speech sounds.

Teaching tip*: Here are a few ways to teach the hypoglossal nerve. Instruct the students to lick a lollipop. To put their tongue behind their alveolar ridge, behind their bottom teeth, and to clean their teeth with their tongue.*

Cranial Nerve Assessment

The Cranial nerve examination is an integral part of any neurological examination [16] as well as all speech, voice, and swallowing examination. The next section will teach students how to perform a cranial nerve examination at bedside or in the therapy room during all speech, voice and swallowing evaluation. At this point application is everything. It is important for the clinician to remember to always use standard precautions when working with all patients.

Olfactory Nerve (i)

To assess olfactory nerve, have a vial of an aromatic substance such as peppermint or coffee. Do not present any kind of noxious substance that would trigger trigeminal nerve function.

Instructions to Patient: *I want you to breathe in and out through your nose. I am going to present something to you to smell. Please close your eyes, occlude one nostril, and take a sniff and then tell me what you smell.*
Clinician has the client to repeat the same on the other nostril.

Visual Field and Ocular Movement

Optic (II) oculomotor (III) trochlear (IV) and abducens (VI).

Instructions to Patient: *I am going to assess how well you are seeing the material that I give to you. I want you look straight ahead and follow my finger as I trace a letter in the air. Follow my finger only with your eyes and not with your head.*

After tracing the capital H in the air, return your finger to its original position and then give the patient the next set of directions. As the clinician moves the finger between the patient's eyes, *tell the patient to follow your finger.*

To assess if the patient is seeing materials in all quadrants, ask the patient to circle all of the ___ (can be letters or numbers) placed randomly about a sheet of paper.

Trigeminal (V) Sensory: A wooden tip cotton applicator or a gloved finger will be needed to assess the three sensory divisions of the trigeminal nerve. The clinician will touch the patient's face bilaterally in all three divisions.

Instructions to patient: *I am going to touch your face in different places. Please close your eyes. I want you to point to where I touch you on your face.*

Trigeminal (V) Motor: To assess mandibular strength and range of motion, give the patient the following instructions.

Instructions to patient*: I want you to open your mouth and don't let me close it. Try to resist me closing your mouth. Now open your mouth and don't let me close.*

The clinician then palpates the temporalis and masseter muscles at a relaxed state. Next, give the following instructions: As I touch you (fingers on temporalis and masseter), I want you to clench your teeth.

Facial (VII): The clinician should assess symmetry of the face as he/she enters the patient's room. Look at the nasal-labial folds and the eyes.

Motor Component

Instructions to the patient: *Please follow these instructions (ask one at a time) wrinkle your forehead; raise your eyebrows, close both eyes tightly, smile and show your teeth, purse you lips like you are kissing, puff up your cheeks with air.*

Sensory component Facial (VII): With a cotton tip applicator, apply a solution of sweet, salty, sour or bitter to each side of the anterior tongue.

Instructions to Patient: *I am going to place a substance on your extended tongue. I want you to tell me what taste it is before you put your tongue back in your mouth.*

Vestibulcochlear (VIII). If the patient is following all of your directions, they may not have a hearing problem. However, here is one way to assess hearing at bedside other than taking to the patient.

I**nstructions to patient**: *I want you to close your eyes and then indicate where you hear a sound. Clinician rubs two fingers together behind the left and the right ears of the patient.*

Glossopharyngeal (IX) Sensory: With a cotton tip applicator, apply a solution of sweet, salty, sour or bitter to each side of the posterior 1/3 tongue.

Instructions to patient: *I am going to place a substance on your extended tongue. I want you to tell me what you taste before you put your tongue back in your mouth. Next, I want you to swallow. The clinician will feel using the thumb and forefinger and feel on either side of the thyroid cartilage, the elevation of the larynx.*

Glossopharyngeal (IX) & Vagus (X): To assess sensory and motor function of the gag reflex, soft palate symmetry at rest and upon phonation, the clinician provides the following instructions. The clinician will assess gag reflex by touching the back of the pharyngeal wall with a tongue depressor. The clinician should also note any spontaneous coughing as a result of any substance presented.

Instructions to patient: *I am going to look in your mouth with a penlight. Please look straight ahead. Now I want you to say 'ah' for 5 seconds.*

Spinal accessory (XI). Head movement. The reason for assessing only head movements is that they are common head postures used in swallowing.

Instructions to patient: *I want you to look straight ahead. Turn your head to the left. Turn your head to the right. Tilt your head back. Put your chin to your chest.*

Hypoglossal (XII). Lingual movement. The clinician should assess the tongue at rest and on movement. The clinician provides instructions for each lingual movement.

Instructions to the patient: *Please follow these instructions: Stick out your tongue; move your tongue from left side of your mouth, now the right side of your mouth; raise your tongue behind your top teeth, now put them behind your bottom teeth; now put your tongue from the front of your mouth all the way to the back of your mouth.*

This paper presented a cursory overview of the cranial nerves and how students can learn the cranial nerves by making it fun and personally relevant. A brief informal way was provided on assessing cranial nerves at bedside. Assessing the cranial nerves can be a powerful diagnostic tool during any speech, voice, and swallowing evaluations. Their functions tell a story of what is going on and how speech, voice, swallowing and hearing can be affected if there is damage to the nerves and muscles. Students should always demonstrate standard precautions when performing their examinations. Once the examination is over, the clinician should thank the patient for allowing them to work with them. The clinician then washes his/her hands and exits the room. Table 1 provides a bird's eye view of the location, modality, function, and impairment of each nerve that the student can use as a reference guide when learning the cranial nerves.

Roman numeral	Name	Location	Modality	Function	Impairment
I	Olfactory	Cerebral cortex (telencephalon)	Sensory	Smell	Anosmia
II	Optic	Cerebral cortex (diencephalon)	Sensory	Vision	Partial or complete blindness in one eye or visual field deficits
III	Oculomotor	Midbrain (mesencephalon)	Motor	Eye movement	Ptosis
IV	Trochlear	Midbrain (mesencephalon)	Motor	Eye movement	Weakness, paralysis of superior oblique muscle, diplopia
V	Trigeminal	Pons	Mixed (Sensory & Motor)	Sensation and proprioception to face, anterior scalp, nasal cavity, eye , oral cavity, moves muscles of mastication, tympani and veli palatini, mylohyoid and anterior belly of digastric	Decrease sensation to face, oral cavity, decrease movement to muscles of mastication
VI	Abducens	Pons	Motor	Eye movement	Medial strabismus, diplopia
VII	Facial	Pons	Mixed (Sensory & Motor	Sensory to skin, external ear, tympanic membrane, taste to anterior two-thirds of tongue, moves muscles of facial expression, lacrimal, sublingual, submandibular glands	Impaired ability in facial expression, decrease sensation to anterior two-third of tongue and mucosa, decrease secretory ability. Lacrimal, sublingual, submandibular
VIII	Vestibulcochlear	Pons	Sensory	Vestibular division: equilibrium Cochlear division: hearing	Hearing loss, balance problems
IX	Glossopharyngeal	Medulla oblongata	Mixed (Sensory & Motor)	Sensation to posterior one third of tongue, pharynx, tonsil, external ear, internal surface of tympanic membrane	Decrease taste to posterior tongue, loss of gag reflex, excess secretion due to poor control of parotid
X	Vagus	Medulla oblongata	Mixed (Sensory & Motor)	Controls muscles for phonation and swallowing	Injury to pharyngeal branch causes paralysis of pharynx and soft palate, dysphagia, unilateral damage to LMN causes breathy voice, hoarseness, diplophonia
XI	Accessory	Medulla oblongata	Motor	Head and neck movement; pharynx	Difficulty turning head for postural swallowing movements
XII	Hypoglossal	Medulla oblongata	Motor	Tongue movement	Difficulty with lingual movement necessary for speech and forming a bolus during swallowing

Table 1: Synopsis of cranial nerves

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