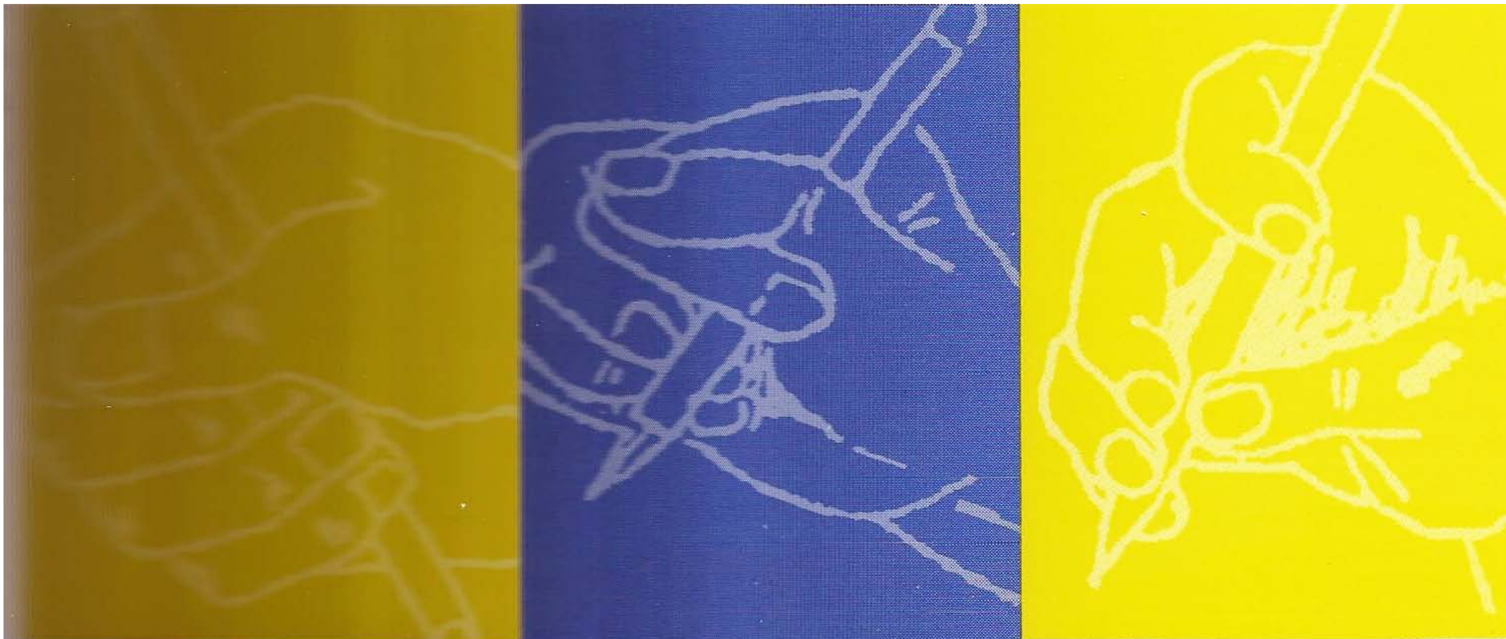


CLINICIAN'S VIEW • CLINICIAN'S VIEW • CLINICIAN'S VIEW

Neurokinesthetic Approach to Hand Function & Handwriting

Mary Benbow, M.S., OTR

CLINICIAN'S VIEW

NEUROKINESTHETIC APPROACH TO HAND FUNCTION AND HANDWRITING

Presented by
Mary Benbow, M.S., OTR

Understanding the Hand from the Inside-Out
Developmental Activities Based on Hand Anatomy

Mary Benbow, MS, OTR

RELEVANT ANATOMY

Normal use and function of the hand are dependent upon the synergy of many muscles; those acting on the wrist, as well as the digits. The muscles of the wrist are important because they stabilize and prevent unwanted wrist movements, which allow the finger muscles to maintain an adequate length that is favorable for producing tension and prehension. The muscles of the hand and wrist are so closely linked that it is virtually impossible to voluntarily omit a muscle from the synergy of which it belongs. Understanding the anatomy of the hand and wrist is important for appreciation of the intricate and synergistic function of the muscles and joints, which work so intricately to provide functional grasp, release and skilled manipulation.

WRIST EXTENSORS AND FLEXORS

Finger movements should work in reciprocal synchrony with movements of the wrist. Grasp is weaker with wrist flexion than with wrist extension. Wrist extension is critical to stabilizing the structure and allowing finger movements at the best mechanical advantage for freedom of range and control.

Children with fine motor and writing problems often lack good wrist stability in extension and therefore cannot activate the most functional finger movements required for skilled manipulation.

To maintain good stability of the wrist in extension for distal finger function, it is necessary for the wrist flexors to work antagonistically with the wrist extensors to provide stable co-contraction and maintain the proper control of the wrist in its best functional position.

EXTRINSIC MUSCLES

The extrinsic finger muscles have their bellies in the forearm. These muscles narrow to pass through the carpal tunnel and into the tendon sheath. They insert on the IP joints of the digits. The extensor extrinsics are responsible for extending the MP joints of digits 2 through 5 and extend the wrist by continued action. The flexor extrinsics flex the PIP joints and the MP joints and the wrist by continued action.

MUSCLES OF THE PALM

The palmar aponeurosis is a fibrous tissue within the palm that is pulled by the palmaris longus, which gathers the fascia as a unit to arch the palm. The brevis draws the skin over the hypothenar eminence to the middle of the palm and also assists in palmar arching.

Intrinsic muscles of the palm function primarily to move the fingers in abduction or adduction in relation to the midline axis of the hand. The palmar interossei, dorsal interossei and lumbricals function to provide delicate coordination of the digits in abduction, adduction, flexion of the MP joints while extending the PIP joints, shape the fingers to fit objects, control tension between the finger flexors and control precise balance between the thumb and index fingers.

INTRINSICS OF THE FIFTH DIGIT

The little finger and the thumb have a special relationship and add to the grasp and balance of the hand. The flexor digiti minimi, abductor digiti minimi and opponens pollicis & digiti minimi are referred to as the hypothenar muscles. They work in synergy to flex the MP joint of the 5th digit, abduct the fifth digit and rotate the fifth MC joint at the CMC joint for opposition to the thumb.

EXTRINSIC MUSCLES OF THE THUMB

The extrinsic muscles of the thumb all have their origin in the forearm. The extensor poillicis brevis and longus extend the MP joint of the thumb and radial deviates the wrist. The abductor pollicis longus abducts the CMC joint, radially deviates the wrist and assists in slight flexion of the wrist. The flexor pollicis longus flexes the IP joint of the thumb and the MP and CMC joints by continued action.

INTRINSIC MUSCLES OF THE THUMB

The intrinsic muscles of the thumb are the abductor pollicis brevis, flexor pollicis brevis and opponens pollicis. These three muscles make up the skill triad and provide rotation of the thumb at the CMC necessary for active opposition, manipulation and delicate touch. The adductor pollicis is a power muscle and adds strength to opposition.

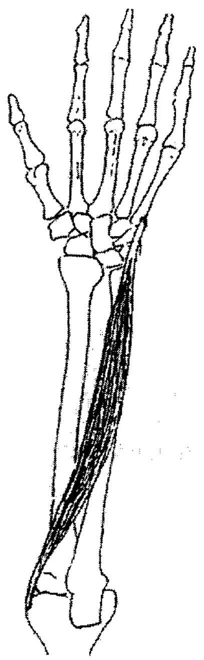
HAND MOVEMENTS

The structure and function of the anatomy of the hand and wrist are responsible for an almost infinite combination of skilled movements of the digits, supported by stability of the wrist and elbow, arches of the hand and the joints of the upper extremity. If one considers the intricate movements of the hand and its skills, the many problems, which can arise in writing and manipulation, can be appreciated.

Children with dysfunctional hands show typical symptoms of a lack of neuromuscular maturity. The arches of the hand are often flat and incompletely developed. There is also a lack of motoric separation between the radial and ulnar sides of the hand. The internal stability of the hand is often in the low normal or low tone range. A related problem is in establishing good wrist stability. The digits often lack controlled flexion/extension and rotation, which are critical for manipulation. Each child must be carefully assessed for the specific degree and area of dysfunction, so that appropriate developmental hand activities can be used to prepare, strengthen and develop the components of functional hand, wrist and finger movements.

WRIST EXTENSORS AND FLEXORS

EXTENSOR CARPI ULNARIS

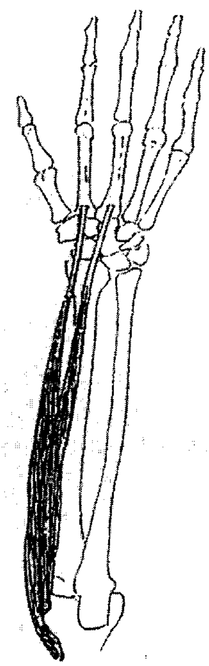


Function:

- Extend wrist
- Ulnar deviation of wrist
- Work synergistically with the thumb triad.
- Stabilize wrist for skill.

EXTENSOR CARPI RADIALIS LONGUS

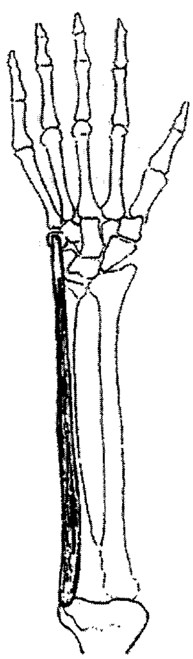
EXTENSOR CARPI RADIALIS BREVIS



Function

- Extend wrist
- Radial deviation of wrist (L)
- Stabilize wrist for power (B)

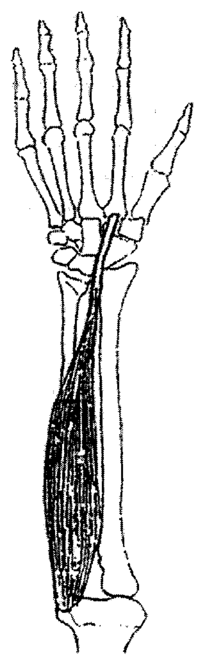
FLEXOR CARPI ULNARIS



Function:

- Flex the wrist.
- Ulnar deviation of wrist.

FLEXOR CARPI RADIALIS

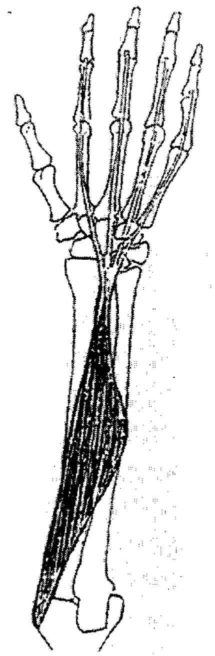


Function:

- Flex the wrist.
- Radial deviation of wrist

EXTRINSIC EXTENSORS OF DIGITS

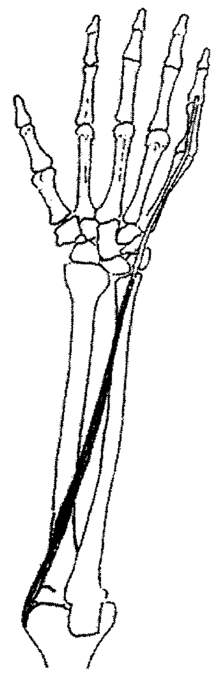
EXTENSOR DIGITORUM COMMUNIS



Function:

- Extend MP of joints of digits 2, 3, 4, 5.
- Extend the wrist by continued acton

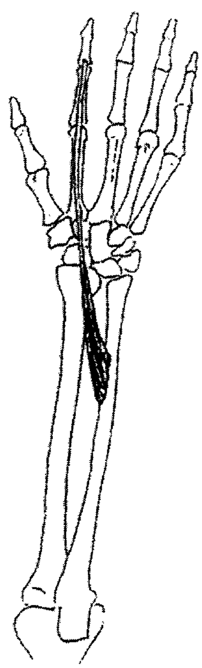
EXTENSOR DIGITI MINIMI PROPRIUS



Function:

- Extend MP joint of digit 5.
- Extend wrist by continued action.

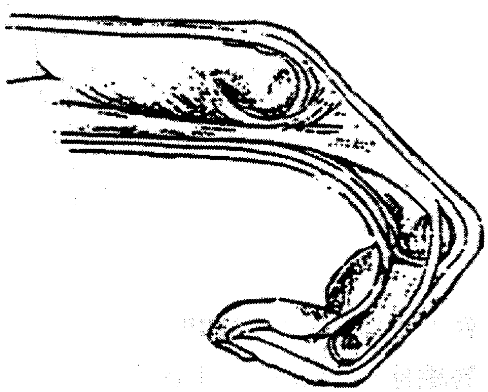
EXTENSOR INDICIS PROPRIUS

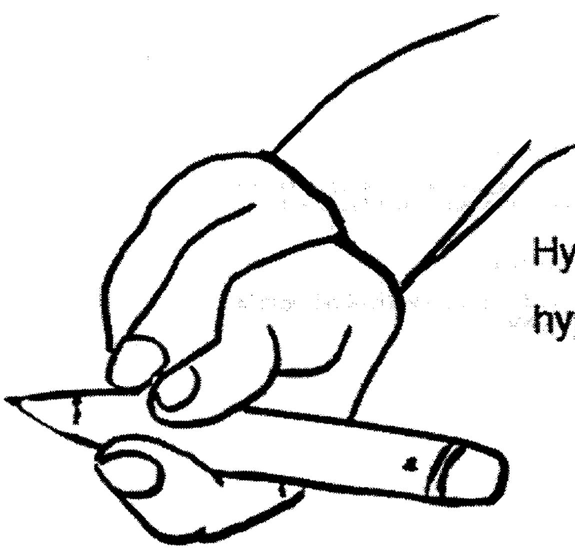


Function:

- Extend MP joint of digit 2
- Extend wrist by continued action.

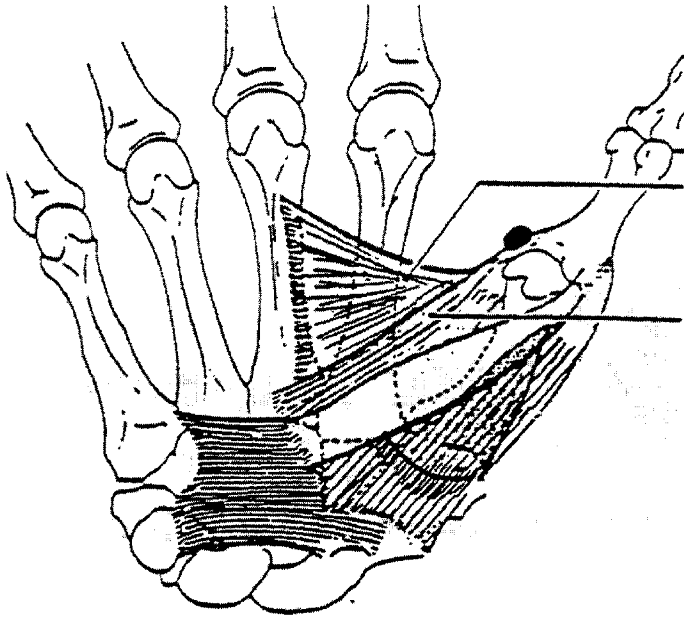
JOINT POSTURES AS THEY RELATE TO POSITION OF LATERAL BANDS





Hyperflexion of the PIP joint yields hyperextension of the DIP jiont.

POWER MUSCLES OF THE THUMB



The ULNAR nerve innervates the two heads of the adductor to:

DRAW THE THUMB METACARPAL TO THE INDEX METACARPAL

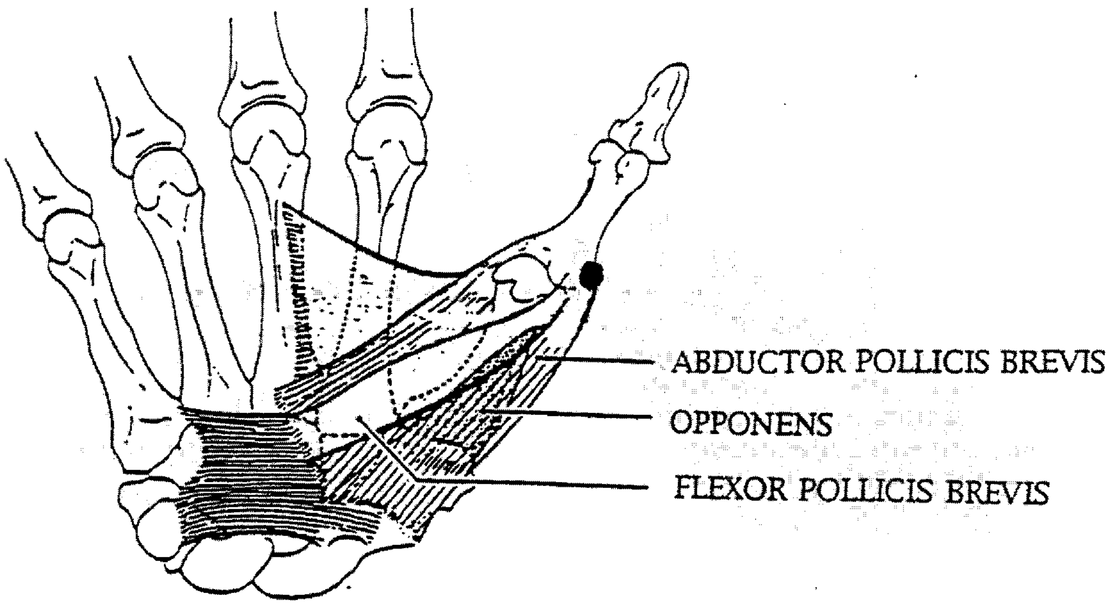
SUPINATE THE THUMB

REINFORCE THE GRIP AT THE END OF OPPOSITION

INSERTION -- WITHIN THE WEB SPACE OF THUMB

From: Tubiana, 1984

SKILLED MUSCLES OF THE THUMB



The MEDIAN nerve innervates TRIAD muscles to:

OPEN THE WEB SPACE
with aid of AB. P L & E P B. Ext. Carpi Ulnaris works synergistically with the triad.

PRONATE THE THUMB

POSITION THE THUMB FOR DISTAL MANIPULATION

INSERTION -- OUTSIDE OF THUMB

From: Tubiana, 1984

ANATOMICAL BALANCING MECHANISMS FOR HAND FUNCTION

FOREARM
The radial INNERVATED supinator works in balance with the median innervated pronator teres.

WRIST
Prime stability at the wrist comes from the wrist extensor located diagonally opposite to the side of the hand, which is functioning. Therefore, when the radial digits (ii & iii) and thumb are manipulating, the extensor carpi ulnaris serves as the prime stabilizer. When the ulnar side of the hand is incorporated for power, the extensor carpi radialis brevis is the prime stabilizer. Anatomical fixed and mobile structures within the hand allow it to rotate around its "midline."

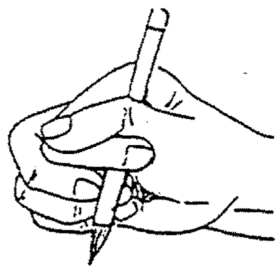
RADIAL DIGITS
Carpometacarpal joints are essentially fixed to stabilize the palm in opposition and provide the proximal stability for the highly mobile MP joints of digits ii & iii.
Metacarpal phalangeal joints are diarthrodial and they are very mobile to allow movement in three planes.

ULNAR DIGITS
Carpometacarpal joints are mobile
Digit v range of motion is 25-30° of motion at the little finger articulation.
Digit iv range of motion is 15° at the ring finger.
Metacarpal phalangeal joints are diarthrodial joints. They are less mobile than the radial MP joints but allow limited movement in three planes.

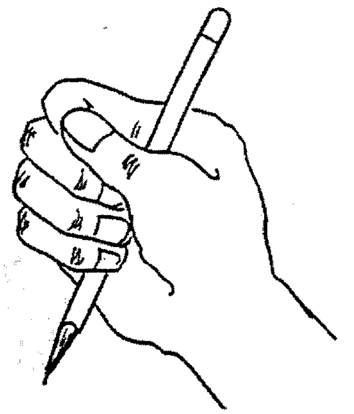
THUMB/FINGER STRENGTH BALANCE
Thumb: the intrinsics muscles are the stronger group.
Fingers: the extrinsics muscles are significantly stronger.
Finger strength: the longer the finger, the stronger the finger

Whole hand function: the peripheral digits i and v balance each other in total hand patterns.

INEFFICIENT GRIPS

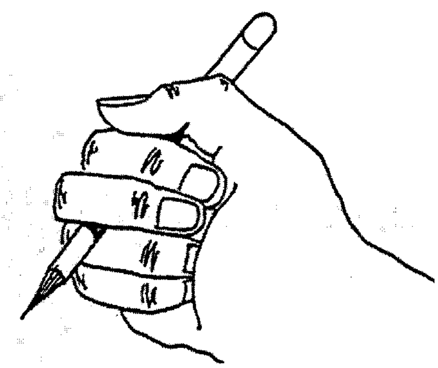


THUMB WRAP

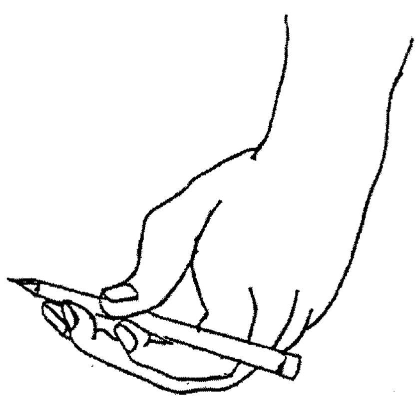


TRANSPALMAR

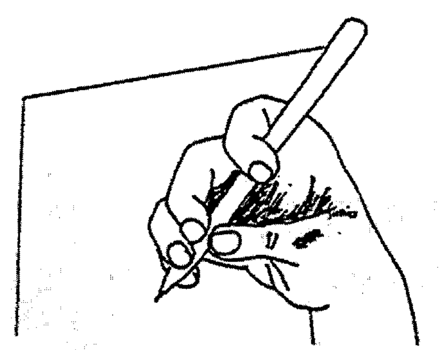
THUMB TUCK



INTERDIGITAL BRACE



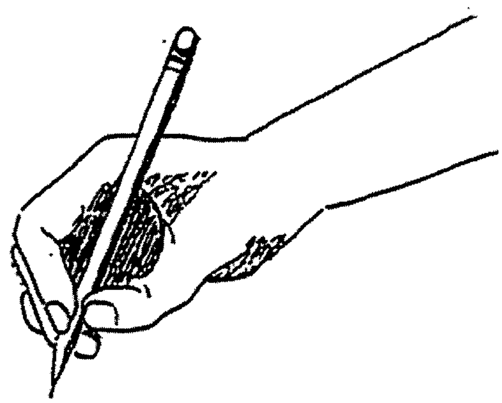
SUPINATE



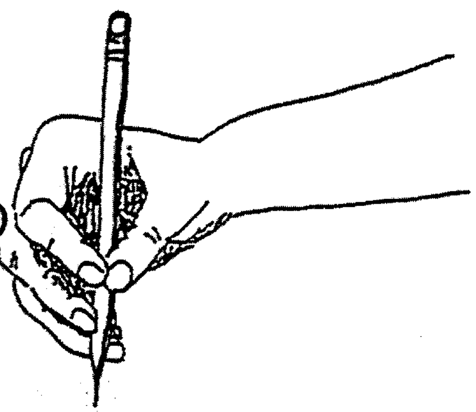
INDEX GRIP

EFFICIENT GRIPS

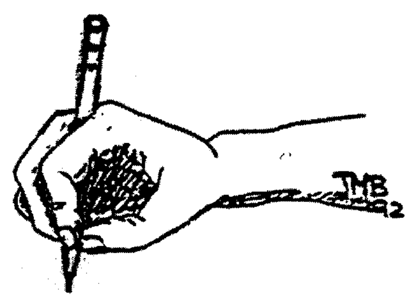
TRIPOD



QUADRUPOD



ADAPTED TRIPOD



Altering an Inefficient Grip

In development of motor skills, there is evidence of transfer between different forms of action. The precision grip once mastered and reliably used with a spoon begins to be used in drawing with a pencil. Therefore the instructor or therapist should evaluate the child's skills in use of a spoon or fork before attempting to alter the more complex skill with a writing tool. Silverware requires only stabilization with the skilled digits. A writing tool requires stabilization with mobilizing. If the child uses an immature power grip on a spoon, the instructor should develop this sub-skill before advancing to writing tools.

Hand structures required for tool stabilization with distal manipulating are:

a) Active metacarpal phalangeal arch with three degrees of freedom (flexion/extension, adduction/abduction, and rotation) at the metacarpal phalangeal joint of the index finger.

b) Full range of motion at the carpal metacarpal joint of the thumb is required to stabilize the open web space. Conditions a & b may require therapeutic intervention with specific developmental activities to achieve the desired results.

c) Joint stability; a most prevalent finding is ligament instability within the joints of the hands. Shifting the pencil into a more stable web space between the index and ring fingers is often a convenient intervention. In severe cases the use of a neoprene splint, as an outside stabilizer may be required.

Before intervening with a student with an inefficient grip, it is critical for him to understand why it is worth his effort to change it. Pencil grips that are not held within the pulps of the digits do not lead to economy, variety and convenience for proximal-distal axis in the simple flexor or extensor synergy to produce fast enough writing needed once the output demands increase about third grade.

An adducted grip (which diminishes the proprioceptive input from the lumbricales from the skilled digits) does not allow the luxury of the unconscious regulation of the gripping pressure on the shaft of the pencil or the downward pressure of the pencil point against the writing surface. This is the reason many students frequently need to stop, release their grip on the pencil and shake the pain out of the fingers. He should be made aware that power grips might result in painful joint dysfunctions later in life due to the stress they cause to the support structures of the joints.

The following sequence can make the transition to the functional grip less stressful and more successful.

1.The instructor demonstrates how to position a pencil between index and long finger to make large random patterns on the paper using only shoulder and elbow movements.

2. The child imitates the instructor by positioning the between the same two digits to make large free flowing movements (no finger movements, letter or number symbols are allowed).

3. After the child adjusts to the feel of the pencil in the index/middle finger web space, she should be encouraged to draw anything she pleases.

DEVELOPMENTAL HAND PROGRAM

The developmental hand program consists of over 65 activities designed to improve hand function, dexterity and control. The activities are divided into 9 sections, including proximal control of the shoulders, the elbow and the wrist, distal finger movements, precision translation, precision rotation, motoric separation of the two sides of the hand, thumb activities and joint stability within the hand. Activities are easily chosen based on the observation of hand skills assessment previously described. Each of these activities is clearly explained and demonstrated in the video "Developmental Hand Program," by Mary Benbow, and available from Clinician's View®.

The human hand is dependent on multiple factors for sensibility of adjustment, economy of execution and accuracy of skill. This hand program has been developed to guide professionals in systematic assessment and inclusive activities to enhance the varied components of fine motor skills of children.

OVERALL DEVELOPMENT

Developmental therapists, trained to look at the whole body and its interrelationships, must address ergonomic factors (postural, tonal, and stabilizing) for fine motor intervention to be most effective. Fine motor difficulties listed in this handout will focus on incomplete utilization of the proximal joints of the upper extremity, immature hand development and lack of joint stability. Commonly related developmental issues such as bilateral integration and visual-motor in coordination will not be addressed in this handout.

PROXIMAL JOINT CONTROL

The development of dexterous hand skills depends on the interaction of all joints of the upper extremity: scapulothoracic, glenohumeral, elbow and wrist. Every joint must move freely into its mature pattern (s). Therefore, each joint should be assessed for functional mobility as it is incorporated in mature upper extremity patterns. In children who experience fine motor delays, it is common to find the shoulder slightly biased in internal rotation, adduction and/or flexion; the elbow in pronation and/or flexion; and the wrist toward flexion and ulnar deviation.

In addition to adequate range of motion, every proximal joint must provide a stable base of support for the joint(s) distal to it to enable maximal control. Proximal joint instability is best treated in an adapted physical education setting with weight bearing, traction and compression type activities.

SCAPULA/SHOULDER ACTIVITIES

1. BALL TAPPING: The child uses a 12" to 14" stick braced between the palms of the hands to gently tap a suspended 8-10 inch ball. The ball should be hung at a level that will require as full elevation of the arms as the child is capable of controlling. Gentle tapping will demand more mid-range control while developing more stable scapula and shoulder joints.

2. MIRROR ARM PATTERNS: Pair off. The instructor initiates a slow symmetrical movement sequence with her arms for the child to follow as if looking in a mirror. Reverse the "leader/follower" roles. Grade by working at a higher level and/or at a slower pace. An advanced goal would be for observers to detect which person is the leader of the sequence.

3. PRECISE POURING: (Pouring from a pitcher or a watering can requires controlled distal mobility, or proximal stability). Fill the container to the level that challenges the strength limitations of the child. Pour colored water into several small containers without spilling between them or overflowing their rims. Work for accuracy with more fluid (weight) in the container and/or reduced quantity containers.

4. SPHERE ON SPOON CARRYING: Carry a round ball, marble, or stone at arm's length on a long handled wooden spoon. Grade by positioning the grip more distal from the bowl of the spoon, increasing the weight of the sphere or distance to be traveled. A final goal could be to carry a heavy sphere to a target with the eyes closed.

5. ROPE TURNING: Turn one end of a jump rope with a partner. The child should first use his dominant hand to develop external rotation of the dominant side shoulder. Then he should turn to use the non-dominant hand to develop the other shoulder.

6. ROPE JUMPING: Self-swing a jump rope. (The handles of the jump rope should touch his armpits -when the child stands with feet together with the middle of the rope passing under the arches). Swing the rope backwards over the head. Reverse swinging requires movement of all upper extremity joints into their mature patterns. Initially, the child should concentrate only on swinging the rope. When he hears the rope strike the floor behind himself, he should step backwards over it.

7. **PLAY BOY:** The elliptical form is forced to opposite ends of the strings when the child abducts at the shoulders. The handles can be positioned from shoulder elevation to shoulder depression. Lying supine is most beneficial for the child with low tone who has scapula instability, poor balance, or isolated control of his upper extremities.

8. BLACKBOARD SHOULDER LOOPS: Produce external rotation loop (overhand) patterns with chalk on a blackboard. Start at eye level and midline and move as high and wide as the reach will allow. Work for pattern smoothness and uniformity. Close eyes and continue patterns kinesthetically.

ELBOW ACTIVITIES

1. SLINKY: The metal slinky should be shifted back and forth while being maintained in a full palm up position.

2. MAGNET STICK FOR VISUAL TRACKING: The child horizontally holds the tracking card with his non-dominant hand to guide a metal object along a printed track. He guides the metal object by sliding a magnet (glued to one end of a stick) from beneath the card track. The magnet stick should be held in a tripod posture with the dominant hand. Start by guiding a flat metal object (paper clip or safety pin), which requires less exact supination. Advance to guiding a tiny metal ball, whose tangential contact demands maintaining the magnet stick in precise supination.

3. TRACK IT: The tray containing a template and slider should be supported on forearms with fully supinated palms while being shifted to the new stimulus-directed position.

4. VOLLEY BALL STYLE ACTIVITIES: Games where the hands, paddles or rackets are used in a full palm-up position.

5. ROLLING SUPINATION: Sit straddled on an 8” stool or roller. Lean forward and take weight onto pronated forearms placed on an 18"-20" vestibular ball. From this "prone on elbows" position, slowly shift weight sideways by rolling the ball under the forearms to the right. This will supinate the (R) elbow and free the (L) arm. Increase supination range of motion by holding the joint position at the end of its range. Alternate sides.

WRIST ACTIVITIES

No other upper extremity joint can compensate for wrist limitations Therefore, careful evaluation and remediation must focus on this joint. Children with fine motor delays often compensate for inadequate stabilization of the wrist in the extended position by flexing the wrist to stabilize bone on bone. Lack of stabilization in wrist extension will compromise abduction of the thumb, arching of the hands, and isolation of intrinsic motor control. The extensor carpi ulnaris (ECU) is the prime stabilizer of the wrist when the index or index and middle fingers are working opposite the thumb. ECU works synergistically with the thumb triad (abductor pollicis brevis, flexor pollicis brevis and opponens) for precise manipulation.

A flexion/extension interplay should be seen between wrist and finger movements as the hands are being used. The wrist and hand function as a single physiological unit, so therapists should combine wrist with hand movements into fine motor activities.

1. FLOOR ACTIVITIES: Large chalkboard or mural painting are age appropriate activities that can best be accomplished on the floor.

2. TOWEL SCRUNCHING: Place a tea towel lengthwise over the far edge of the child's desk. With forearm stabilized in full pronation (palms down) on the desk top, use finger flexors to gather the towel into the palms. As more towel is gathered, more finger flexion with wrist extension will be incorporated into this task.

3. DONKEY KICKS: Instruct the child to place his hands on a mat directly below his shoulders, with fingers pointing straight ahead. He should take his body weight onto his open palms and his tiptoes. His ankles should be touching each other at all times during this exercise. Start with both feet to one side and "kick" up and over to the opposite side of the mat. With practice, his kicks will become higher and his wrist flexors more elongated.

4. VERTICAL SURFACES: The wrist will be positioned in fuller extension the higher the child works on a vertical surface above eye level. Games and art materials can be mounted in a clipboard, set in a railing, or taped to a non-porous vertical surface. Suggested materials might include pegboards, Lite Brite, Etch-A-Sketch (turned upside down so knobs are high), Magna Doodle (turned upside down so eraser bar is high), threading eye hooks, outlining before coloring, circling, filling in small circles, and writing high with chalk on a blackboard and drawing or painting at an easel.

DISTAL FINGER SKILLS:

Wrist stabilization combined with fine manipulative activities should develop the essential hand components for all high level hand skills: The components: A) develop and stabilize the arches of the hand, B) develop the two divisions of precision handling - precision translation and precision rotation; C) motorically separate the two sides of the hand, and D) open and stabilize the thumb-index web space.

A) ARCHES

There are two transverse arches, four longitudinal arches, and four diagonal or oblique arches of position. The arches: 1) shape the hand to grasp multiple shaped and sized objects, 2) direct the skilled movement of the fingers, and 3) grade the power of prehension. Well-developed arches enable the palm to form a deep hollow at the base of the long finger and distinct crease between the thenar and elevated hypothenar eminences when the hand is cupped.

1. PALM SHAPING: Press a ball or round object into the child's palm. Facilitate arching of his hand by stroking or shaping it into an arched posture with your hands. A gummy super-ball is a most effective texture to elicit the child's natural tactile affinity for this activity.

2. PALM LOADING: Cup the supinated palm so that a deep hollow is formed at the base of the long finger. Gradually add grains of rice or coffee while encouraging the child to make the hollow deeper to hold more. This activity should facilitate CMC flexion of the 5th metacarpal and wrinkling of skin on the little finger side of the palm.

3. SHAKING DICE: Be sure the fingers are adducted and incorporated in the longitudinal arching. Cup both hands before placing them together at a 90-degree angle to each other. Maintaining the arches and the sealing of the borders of the hands will allow the dice to shake within the palm without being dropped.

4. DOMINO THEORY: Arrange dominoes on their narrow end about 1/4 inch apart in a long line. By pushing the first in the line one should see a chain reaction of them falling in order.

5. PLASTIC BAG SEALING: Bilaterally seal Zip-Lock Bags. Pinch the grooved ridges together at the middle, the thumb pulps working opposite the finger pulps. During successive trials, work with the thumbs opposite each finger pulp from index to little finger. Encourage maintaining a rounded thumb web space as you seal the bag. Color change seals are best.

6. TOWER BUILDING: Hold chisel erasers between each thumb and index finger. The point’s ends should be positioned toward the web space. Pick up tiny cubes or dice from a table surface by compressing them between the round open ends of the erasers. Stack the cubes to build a tower. Controlled bilateral release is essential for the tower to reach great heights.

7. SPIDER ON THE MIRROR: (One forearm should be fully supinated and the other fully pronated to do this exercise.) Place like finger pads of each hand together. ABduct and ADDuct extended fingers. Some flexion/ extension will happen at the MP joints as part of this finger pattern, as the deep hollows are formed at the bases of the two long fingers.

8. THERAPLAST BALLS: Shape a 3/4" sphere by cupping the hands (including the fingers) within the hollows of the hands. Grade this activity by dividing the putty and simultaneously shaping two balls with the two hands.

9. CHINESE BALLS: Use two 3/4" marbles, wooden beads or super balls in each hand. Rotate one ball around the other within the palm(s). Different colors help the child motor plan and determine if they are rotating around each other. The rotation pattern that requires the thumbs to move toward the middle of the palms will require use of the triad muscles of the thumb.

HAND TOOLS

Many hand tools are held using an oblique arch of opposition. (This grip is customarily assumed to cut food with a table knife). The tool handle is positioned diagonally across the palm with the index finger extended to provide stability and downward pressure to perform the task. The material to be cut must be soft enough so that an ADDucted lateral pinch will not kinesthetically be substituted for additional power to perform the task.

10. WINGED CLOTHESPIN: Glue a cross bar (half a Popsicle stick) onto the end of the handle of a wooden clothespin. The child should place four finger pulps on this affixed cross bar and his thumb pulp on the opposite handle to open the clothespin. This posture will strengthen the thenar muscles as the child works.

11. DRESS MAKER'S WHEEL: Guide a Dress Maker's wheel to serrate heavy paper for easier tearing. Using dress maker's colored paper, guide the wheel to make colored dotted designs.

12. STRAWBERRY HULLER: Arch the fingers to the same length. Place the four fingertips on one side of the implement with the thumb on the opposite side. Pick up small objects of various textures without crushing them and move them to another location or stack them.

13. ESCARGOT HOLDER: Place four finger pulps on one side of the handle with the thumb pulp on the opposite handle. This posture will strengthen the thenar muscles as the child picks up and transfers objects.

14. ROOKIE STICK: The two legs of this device will guide an open web space while developing delicate touch with small objects.

15. OLIVE & PICKLE PICKER UPPER: This plunger device can direct resistance to specific areas of the thumb triad while maintaining control of distal pressure.

16. PLASTIC KNIFE CUTTING: Cut clay, putty, bread or partly cooked carrots etc. with a "fast-food" restaurant knife. The tool handle is positioned diagonally across the palm with the index finger extended to provide stability and downward pressure to perform the task. The material to be cut must be soft enough so that an ADDucted lateral pinch will not kinesthetically be substituted for additional power to perform the task.

B) PRECISION HANDLING (TWO TYPES)

Distal precision handling requires full range of motion at the carpometacarpal joint of the thumb. Full abduction with medial rotation positions the thumb so it can be placed diametrically

Understanding the Hand from the Outside - In

Teaching Strategies Based on Neuroanatomy and Hand Anatomy

Mary Benbow, MS, OTR

VISUAL/VISUALIZING CONCERNS IN HANDWRITING

Copying from the chalkboard (vertical plane) while writing on a desk surface (horizontal plane) requires plane' integration (a parietal lobe dysfunction) to follow the spatial directions; or the problem may be an accommodative difficulty with the needed to alternate between near point and far point vision. In severe cases, both eyes may be drawn to the (R) when elevating the eyes to read from the board.

Passivity or inertia of gaze is often seen with incomplete (L) scanning or inattention. A progressive sloping of the (L) margin into (R) space will be seen as the writing moves down the page.

There may be a problem with spacing of letters within and between words in manuscript; irregular spacing of words in cursive.

Diagonals {especially (L) downward sloping} are often avoided. When used, their execution will approximate the vertical. This will make producing manuscript letters more difficult than cursive letters.

Gestalt, the overall pattern of the letters or designs will be disrupted. Elements or parts will be strung out in printing letters or drawing designs or shapes.

Multi-step directions are often forgotten or incorrectly sequenced because the student did not visualize the steps to support the verbal directions given by the teacher.

MEMORY AND HANDWRITING

It is the category of "procedural memory" that is most relevant to handwriting.

PROCEDURAL MEMORY

Implicit: This memory is for automatic recall of a series of movements such as riding a bike, typing, swimming, tying shoelaces, driving, or writing cursive script. When handwriting is taught to the automatic kinesthetic level, the student is using implicit memory. This allows him to free up working memory and focus his full attention on the thought he wishes to record or the words he must spell. As long as a student has to shift his attention between remembering how to produce letter configurations and formulating an idea he wants to express, he will be at risk for "output failure." In taking class notes or copying from the blackboard, he will not be able to function at the level of his true potential. Students who develop the skills of cursive writing to the automatic kinesthetic level will be able to function more effectively at academic and life tasks. There is minimal erosion of this type of memory over the life span. Though physical changes of aging may make handwriting difficult, an older person typically continues to have procedural memory for cursive writing such as **a** legal signature.

Working: Working memory is used when the brain's "conductor" tells it where to shift focused attention moment by moment while performing a task. Working memory is needed to keep several things in mind simultaneously with one or more components "shifted to the back burner." An example is remembering the subject of a sentence while writing the predicate. In written schoolwork, problems arise when a student must also have to recall how to spell a word and configure the letters. The student will be overwhelmed and discouraged by these multiple demands when speed in note taking is required or an increased amount of written material is expected.

ATTENTIVELY STORED MEMORY

Semantic: The memory of words, symbols and trademarks. One tends to add words to semantic memory throughout life. This type of memory is highly resilient throughout the life span.

Remote: The memory needed to win big on "Jeopardy". This includes the rapid recall of facts collected from reading, movies, school courses and everyday exposure to the world. Decline of remote memory may simply be a retrieval problem.

Episodic: This is the memory of recent events-the name of the video you viewed last week or what you ate for dinner last night. You may well remember how to drive (implicit memory) but forget where you parked your car. Loss of episodic memory troubles many people. Reduction of episodic memory will make learning a new task slower than when the person was younger.

Handwriting Observations
Assessment of Cursive Writing Skills
Developed by Mary Benbow MS, OTR

EQUIPMENT REQUIRED

- Appropriate sized desk and chair
- Stop watch
- Pencil
- Prism scope
- 2 Production Consistency Sheets
- Small piece of soft putty or clay
- Round fine tip marker
- 2 identical wooden stem tops
- Distal Finger Control Sheet
- Visual Motor Orientation Sheet

PHYSICAL OBSERVATIONS & NOTES	Yes	No
1. ELBOW SUPINATION: {Child standing} Evaluator flexes the child's elbows to 90 degrees and passively rotates each forearm to full palm up position. NOTE if movement at either elbow seems resistant at end range. From this flexed elbow position, instruct the child to actively turn each of his forearms to its full upright position. NOTE any shoulder(s) compensation. *Camera slightly off to side but wide enough to observe elbow and shoulder movements.*		
2. WRIST STABILITY IN EXTENSION: {Child seated at appropriate sized desk} Have the child stabilize his flexed elbow on the desk top at eye level. The child is instructed to roll out a pea sized ball of clay or putty between his thumb and index finger pads. *Camera should be facing the child's hand* NOTE a) position of the wrist and b) stabilizing technique the hand assumes to isolate control at the metacarpophalangeal arch.		
3. ABDUCTION OF THE THUMB IN THE PLANE OF THE PALM: The child holds his hands up in front of his face with his fingers pointing straight up. From this position, he should separate his thumbs from the sides of his hands as far as is comfortable. NOTE the degree of separation of the thumbs from the sides of his hands. The thumb angles should approximate 90 degree "L" and reverse "L" shapes. *Camera angle should be straight on.*		

PHYSICAL OBSERVATIONS & NOTES	Yes	No
4. DEPTH OF ARCHES OF THE DOMINANT HAND: Instruct the child to bring his thumb pad into approximation to his little finger pad but not quite touch them together. He will need to see into his own palm to monitor this task. NOTE the depth of the "hole" at the base of the long finger and the movement of the hypothenar eminence. *Camera should aim directly into palm to observe the "hole" at the base of the long finger and little finger side of the palm.*		
5. SNAPPING FINGERS: Instruct the child to snap his fingers while stabilizing his flexed elbow on the desk top at eye level. *Camera aimed into palm.* If he is able to snap, have him repeat it slowly a few more times. NOTE: a) separation of the ulnar digits from the radial digits, b) pad to pad positioning, c) extension of index finger in isolation from the long finger and d) thumb CMC abduction.		
	R	L
6. FINGER SUCCESSION TASK (TIMED TASK): Teach thumb touching in succession to each finger tip starting with little finger "5" and moving across to 4, 3, and 2 back to 5 to continue. Practice until the child gets the idea of continuing the pattern as quickly as possible. Instruct the child to stabilize his bent elbows and position his hands forward outside his peripheral visual field. During timed trials, the child is asked to "Keep touching each finger in succession until I tell you to 'stop'". Record the number of seconds after "go" to complete 5 sequences (20 touches) (dominant hand and then non-dominant hand). *Camera is aimed directly opposite the child's raised hands to record* s *unilateral smoothness and synkinesis* .		
DOMINANCE	R	L
7. SKILLED HAND: Instruct the child to spin a simple wooden stem top 5 times in order to observe refinement of his spinning patterns. NOTE a) hand spontaneously used and b) if he spins toward the body midline in a pronated pattern or away from the body in a supinate pattern and which fingers are placed on the stem of the top . Encourage him to practice with his other hand (non dominant) a few times. Now give him two identical tops to spin simultaneously. *Camera should be focused to the desk top for spinning activity.*		
8. SIGHTING EYE: Instruct the child to hold a prism scope with both hands to view. NOTE the initial eye spontaneously used. Now ask the child to look with his other eye to observe: a) if the recessive eyes sees about the same as the dominant eye, b) if the child shifts his head and eye to a lateral position in order to sight, or c) child reports that he cannot see with his recessive eye. *Camera should focus of the child's eye and neck posture.*		

DIAGNOSTIC OBSERVATIONS BY LETTER GROUPS

GROUP: CLOCK CLIMBERS

RANGE OF MOTION--Children who have trouble rounding strokes over the top between 11 and 1 o'clock often are tight in forearm supination, index metacarpal phalangeal rotation and/or thumb abduction. Any closed web pencil grips severely limit rotation of the pencil point. Therapeutic intervention is usually indicated.

DIRECTIONALITY--Continuous pattern, "roller coaster" or wrap-around letters are not used in cursive writing. Children delayed in developing directionality typically make a continuous pattern. Often this motor behavior has no developmental basis but is a carry-over from forming manuscript letters incorrectly at an earlier stage. Children tend to generalize this pattern to the Clock Climber group. This needs to be corrected immediately.

INTEGRATION OF THE DIAGONAL WITH SPACE RELATIONS-Children who have not developed perceptual-motor integration of the diagonal will compensate by stopping the top round stroke short of 1 o'clock or continuing the bottom stroke past 6 to 5 o'clock. This will set the pattern for a vertical excursion to 1 o'clock. Generally the child is unaware of his avoidance of the diagonal. A clock face design is a valuable aid for teaching this group. It gives spatial reference for all the rounded segments and the child should sub vocalize as he practices.

EYE HAND COORDINATION-Children slow in developing motor proficiency usually benefit from being coached as to the ideal speed at which to perform an action. Graphic learning can be facilitated by guiding the novice writer when to move his pencil quickly and slowly. Once the child can visualize the progression of the letter, he should be coached to make a speedy lead-in as he curves up and over to 1 o'clock. This will facilitate kinesthetic learning and reduce the tendency to "draw" the letter using a visual-motor approach.

GROUP: KITE STRINGS

PERCEPTUAL MOTOR INTEGRATION OF THE DIAGONAL-Children delayed in this area will want to move up from the writing line with a slower vertical stroke rather than a faster diagonal strike. It will help to have the class visualize the difference between the way a helium filled balloon and a kite behave when held on a string. The balloon goes straight up from the hand but the kite swoops away from his hand. To encourage more slant visualize a stronger wind.

DIRECTIONAL CHANGE IN CONTINUOUS FLOW PATTERNS-Children who are not well integrated have difficulty changing direction in a line flow pattern. In this group "r" and "s" require abrupt shifts in direction. Stopping at the starred points allows time for visual-motor reorganization so that the necessary shifts can be made precisely. If this teaching step is included, children will have success with these demanding letters.

GROUP: LOOP GROUP

VISUAL MOTOR INTEGRATION OF THE DIAGONAL--Letters "h," "k" and "b" require an obtuse angled lead-in to allow room for the down stroke to cross at the middle marker as it continues diagonally downward to the writing line. The down stroke also must slant left toward the starting point. Letters "f," "1" and "e" require a less obtuse angling of the lead-in because their down stroke crosses the lead-in at a lower angle.

SPACE RELATIONS--Children weak in perceptual-motor skill have difficulty starting to loop as they approach the top of the line. Their tendency is to touch a point before changing a movement progression. The sophisticated level of skill in the upward and reverse turning loop group is best achieve by having the class complete many repetitions of the motor pattern using isolated shoulder movements.

DIRECTIONALITY--After the over-the-top stroke is rounded from 1 to 12 o'clock across the top of the line, it is best to pause before slanting left back to the writing line. This will help correct the natural tendency to continue into right down space.

GROUP: HILLS AND VALLEYS

SPACE RELATIONS--Children need to be shown the subtle but slightly larger angle of the lead-in stroke compared to the down strokes in the main part of these letters.

Children benefit from a visual guide to make multiple units of letters with equally spaced parallel lines. Looking back at the first down stroke in "m", "v" and "y" will help to keep the spacing uniform rather than become wider with successive units of the letter.

HANDWRITING FOR ALL STUDENTS

Functional handwriting must be taught more efficiently, thoroughly and permanently to all school children. This includes the great number of subtly delayed students who have trouble mastering a functional level of graphic skill to function comfortably in school and life. Developmental delays such as incomplete bilateral integration, organizational, memory, analytical and or perceptual motor output should be accommodated for with specific compensatory teaching techniques. With compensatory tips, all students should be expected to learn to write legibly in an integrated classroom setting.

Manuscript before cursive may have a number of negative factors that hinder developing speed and kinesthesia for effective cursive handwriting.

I) The paper is typically positioned square to the desk edge (except for D'Nealian) rather than on a slant to utilize the efficient diagonal draw of the wrist flexors for down stroking.

2) Manuscript techniques require mentally separating letters into their many line units and then joining the line units into letters. This demand is beyond the ability of children with part-to-whole perceptual motor or spacing problems. Cursive writing requires learning letters as whole motor units.

3) Many manuscript letters (including 12 capitals) have diagonal line(s). This is the hardest line orientation to produce and prevents mastery for many youngsters at the age when manuscript is customarily taught in our schools. Cursive writing avoids the most difficult diagonal where the line unit moves into (L) downward space

4) Spatial confusion is compensated for in cursive letters where all lower case letters lead-in from the writing line and move up into right space. With manuscript, spacing is required between each letter and each word. In cursive, spacing is reduced to between words.

5) There are no mirror image letters in lower case cursive formations. "b and d" and "p and q" output confusion is eliminated.

6) Children with right hemisphere spatial difficulties, known to be more rigid in their learning style, have a perplexing task in shifting to a new writing system. Most of these children will have struggled with but never really mastered manuscript in the first two to three years of school. Making such a shift is often beyond their tolerance. Frequently these students will revert to less efficient manuscript when task demands are high. Mixing the two letter systems is also a common finding.

Educators would be sensible to wait for developmental readiness for graphic skills to develop before formal instruction for paper work is expected. Curricula that use instructional techniques to accommodate for perceptual and motor delays and deficits should enable nearly all students to advance to cursive writing at an earlier age. Second grade is the optimal time for most children to learn cursive handwriting. Student interest is high, and typically students have not yet acquired faulty habits of inventive cursive before formal instruction begins. Training activities of combining letters into simple two- and three-letter words to practice letter formations and connector units are at a more appropriate level for second graders. Initiating cursive/instruction in the fall of second grade allows a full year for students to stabilize this motor learning and be prepared for the higher volume of written work expected at the third grade. At this age, if cursive is enthusiastically taught, it can be enthusiastically learned. Dysfunctional writing with its misery and frustration should become obsolete.