Alexia and Agraphia After Luria

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ABSTRACT

Luria investigated the acquisition of reading and writing in children tracing the emergence of these abilities through several stages. In addition to his interests in the ontogeny and anthropology of these skills, he applied his neurodynamic approach to the breakdown of reading and writing in brain damaged adults and described five types of agraphias and eight types of alexias. Each alexic and agraphic syndrome is clinically distinguishable on the basis of a unique pattern of disrupted and preserved skills. Restoration of reading and writing is accomplished according to syndrome-specific strategies. Luria’s approach presaged many current theories of alexia and agraphia.

Luria investigated reading and writing from a developmental perspective as well as through the use of neuropsychological methods in brain-damaged adults. His was a novel approach rejecting both localizationist and holist theories and offering a neurodynamic model of basic components called “analyzers” integrated into systems subserving complex functions. He applied this model extensively to the understanding of alexia and agraphia. This review will describe Luria’s developmental studies, his typology of the varieties of agraphia and alexia and his approach to the examination and restoration of reading and writing. How Luria’s basic neurodynamic principles inform his treatment of alexia and agraphia is considered and his approach to reading and writing is compared with those of contemporary clinical neuroscientists.
DEVELOPMENT OF READING AND WRITING

Luria's interest in reading and writing skills included their ontogenetic and anthropologic history as well as their alterations in brain-damaged adults. His early developmental observations (Luria 1978) provided a background for his later investigations of the effects of brain injury.

To study the "prehistory" of writing, Luria asked four- and five-year-old children who were not yet literate to "write" words and phrases presented by the examiners. These children produced scribbles that were essentially identical for each dictated word. For them, writing was an act of play, an imitation of what they saw adults doing. In this first stage of development, writing is not used symbolically and the child is unaware of its significance as a notation system. Luria called this stage the "preinstrumental phase" of writing development.

In the next phase, Luria noted that the children arranged their lines in geometrical patterns on the page. The scribbles themselves continued to be meaningless, but their positions on the page, situation and relation to other marks imparted some degree of meaning, serving as a memory aid; that is, they could be "read". In this stage of writing, the graphic sign functions as a clue to trigger associations but lacks meaning in itself. This stage of writing development uses the written mark as an "ostensive sign".

As writing is further transformed from undifferentiated scribble into a differentiated sign, the child replaces lines and scribbles with figures and pictures. Luria saw in this sequence of events "the center path of development of writing in both the history of nations and the development of the child". With the development of pictographic writing, the sign-stimulus is transformed into a sign-symbol. In the initial phases of this stage, short words are depicted as short scribbles and long words with longer scribbles, reflecting the rhythm of the utterance. Number and form first appear at this stage of graphic representation: larger numbers are depicted with multiple lines and forms (e.g. trees) are represented by specific denotations (e.g. drawings of branches). Writing at this point is representational, in that the child can encode his experience and later read the notation. This is the period of pictographic writing.

In the stage of alphabetic writing, the child learns individual letters and begins to understand their content. In this phase, Luria believed, the child reverts to an undifferentiated approach in which the letters are learned and the child thinks that anything can be represented by them (as he did with his first scribble). Only later is context associated with the alphabetical notational system. Thus, it is not understanding that generates the act, but the act that eventually leads to understanding. Before the child fully grasps the mechanism of alphabetical writing, he has progressed through preinstrumental, ostensive sign and pictographic stages of
graphic development. Luria suggested that similar phases of development could be seen in the writing of primitive people and that the child retraced the steps of civilization in his mastery of "the most priceless tool of culture".

After this initial mastery by the child, the act of writing undergoes further differentiation. Luria (1980) observed that written and oral speech are profoundly different in their genesis, psychophysiological structure and functional properties. Spoken language is augmented and clarified by inflections, pauses and gestures and typically involves direct visual feedback from the listener. Written language, on the other hand, must stand on its own, unbuttressed by paralinguistic nuances or interactive information. Further, both writing and reading are learned consciously and analytically, so that different skill levels are seen across individuals, whereas speaking and listening are acquired "automatically" by "imitation" of others. Reading and writing are derivative skills developed after the acquisition of spoken language. Differences in the development of spoken and written language explain why many people never become sophisticated in writing and written expression remains vulnerable throughout life to a wide variety of linguistic, cognitive and motoric insults.

In Luria's conception, reading is similar to writing in being "consciously learned" and in being comprised of several stages — links in a chain. Reading and writing are essentially mirrored procedures, related to each other as are the processes of decoding and encoding. Writing begins with a mental concept, followed by the formation of an articulatory-phonetic trace, which is then encoded into a graphemic trace, which in turn is transformed into the written letter (grapheme). Reading is the reverse, transforming "words to thoughts": letters are decoded through these same stages to attain a mental concept. The stages are mediated by different parts of a distributed system in the brain and qualitatively different deficits are to be expected in both writing and reading functions from different lesions.

Both mental abilities are developed to different degrees of facility by different individuals. Portions of reading and writing, particularly the most familiar elements, become "automatic" and are thus less subject to disruption than less familiar, more complex elements. Luria contrasted reading and writing one's name, the acronyms U.S.S.R. and U.S.A. and everyday speech formulae (e.g. "Well, of course" and "That is to say") with reading and writing words such as "distract", "contemporary" and "hepaticogastronomy". A hierarchy of difficulty occurs in both reading and writing and individuals differ in the degree in which these skills have become automatized. Luria does not offer a neuroanatomical explanation for these differences in facility other than to state that the relative parts played by different cortical systems change as development proceeds.

Luria also observed that reading and writing functions differ among languages,
depending on the degree of phonetic systematicity in the written code, with, he often notes, Russian and Spanish exemplifying the most systematic phoneme-to-grapheme correspondences, French and English deviating from this orderliness because of non-phonetic spelling conventions and Chinese serving as the extreme case of the ideographic writing system. To illustrate this, he described a polyglot patient who could write Russian but not French — or, as Luria put it — "phonetically but not nonphonetically". Luria's speculation that "cortical organization" for writing and reading functions would differ for these different notational systems has recently been borne out by research on the Japanese writing system that contains both phonetic and ideographic scripts (Sasunuma 1976: Endo et al. 1981).

Thus Luria contributed to the ontogenetic and anthropological aspects of language function as well as the consequences of brain injury for reading and writing skills.

**AGRAPHIA**

**Varieties of Agraphia**

Luria described five principal types of agraphia, each corresponding to a major aphasic syndrome (Table 1) (Luria 1970, 1973, 1980). The aphasic disorders identified by Luria are (1) acoustic or sensory aphasia (characterized by a speech comprehension deficit); (2) "afferent" motor aphasia (speech production deficit with apraxic features); (3) "efferent" motor aphasia (speech production deficit characterized by initiation and sequencing difficulties); (4) frontal aphasia (a deficit in speech initiation and execution); and (5) semantic aphasia (a deficit at the level of linguistic concepts).

Acoustic aphasia, associated with a superior temporal lesion, involves an "acoustic–gnostic" disturbance and the accompanying writing disorder preserves only those writing abilities independent of language comprehension, while those contingent on comprehension are disrupted. Copying, habitual writing acts (e.g. signature) and number writing are all preserved, whereas spontaneous writing and writing of less familiar words from dictation are abnormal. In severe cases, writing individual letters is difficult and the abnormality is compounded when syllables or words are attempted. Evaluation of letter position within words is poor. Omission and transposition of letters and substitution of phonetically similar syllables are common and aid in distinguishing this type of agraphia from other aphasic writing disturbances. Preventing the patient from using articulatory cues by having him hold his tongue between his teeth (termed "exclusion of oral speech") exaggerates this form of agraphia.
### Table 1
Classification of Agraphias Described by Luria

<table>
<thead>
<tr>
<th>Aphasia</th>
<th>Lesion Site</th>
<th>Underlying Disturbance</th>
<th>Characteristics of the Associated Agraphia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic aphasia</td>
<td>Superior temporal</td>
<td>Acoustic-agnostic disturbance</td>
<td>Abnormal spontaneous writing to dictation; preserved copying, habitual acts and number writing</td>
</tr>
<tr>
<td>Afferent kinesthetic motor aphasia</td>
<td>Rolandic operculum</td>
<td>Loss of articulatory schemata</td>
<td>Letter substitutions; cannot write to dictation</td>
</tr>
<tr>
<td>Efferent kinetic motor aphasia</td>
<td>Inferior premotor</td>
<td>Loss of inner word schemata</td>
<td>Cannot synthesize syllables into words; can write letters to dictation; perseverance common</td>
</tr>
<tr>
<td>Frontal dynamic aphasia</td>
<td>Inferior prefrontal</td>
<td>Loss of verbal initiative and efferent schemata</td>
<td>Omit and reverse letters; may be completely unable to write; micrographia; perseveration</td>
</tr>
<tr>
<td>Semantic aphasia</td>
<td>Inferior parietal</td>
<td>Loss of conceptual and ideational schemata</td>
<td>Cannot write letters; spatial orientation lost; cannot combine letters into words; cannot copy letters</td>
</tr>
</tbody>
</table>

Afferent (kinesthetic) motor aphasia is produced by lesions of the parietal operculum in the inferior Rolandic region. The underlying “damaged link” is a loss of the “articulatory schemata” or an “instability of phonetic traces”. When attempting to write, the patient cannot correlate letters and speech sounds. In severe cases, the patient cannot write at all; in milder cases, the patient fails to
distinguish sounds and writes incorrect letters. He errrs in evaluating the positions of letters in words. In the least severe cases, the deficit is noted only in attempts to write less familiar and/or phonetically complex words. Sound transpositions are less typical of this group than in those with acoustic aphasia. The patient is often aided considerably by saying the words aloud or even by observing speech articulations in a mirror prior to writing the sounds.

Efferent (kinetic) motor aphasia accompanies injury to the inferior frontal premotor cortex and is associated with motor inertia and with derangement of "inner word schemata", so that the patient cannot move smoothly from one linguistic unit (phoneme or word) to another. The agraphia observed in patients with kinetic aphasia is characterized by preservation of letter writing but an inability to combine letters into syllables and words. Correct ordering of letters and words is disrupted even in slight or latent forms of efferent motor aphasia and perseveration is particularly common in this form of agraphia. Exclusion of oral speech has little effect, indicating that the patient is not aided by articulatory cues.

Frontal dynamic aphasia results from damage to the inferior prefrontal area causing a loss of verbal initiative and of efferent motor schemata. The writing disturbance accompanying this syndrome was not conceptualized by Luria as a primary agraphia associated with a language disturbance but as a product of a motor initiation disturbance and loss of motor planning. In some cases, the patient is completely unable to write, but, more often, the writing is characterized by progressive micrographia and perseveration of letters, words or phrases. Script may be illegible.

Semantic aphasia occurs with damage to the occipito-temporal or occipito-parietal regions of the left hemisphere. In this syndrome Luria postulated preservation of the acoustic and articulatory basis of writing alongside a loss of "ideational schemata" with a resultant inability to translate phonemes into graphemes. There is a prominent disturbance of visuo-spatial analysis and individual letters are misplaced or written as mirror images. Correctly executed letters cannot be combined appropriately into syllables or words. Spontaneous writing, writing to dictation and copying of written material are all comparably impaired. The deficits are exaggerated by exclusion of oral speech.

Investigation of Writing

Luria emphasized the usefulness of a thorough investigation of writing skills both as an aid to aphasia diagnosis and as a preliminary step in formulating a rehabilitation plan (Luria 1970, 1980). The principal observations in each agraphia type are shown in Table 2. The investigation begins by testing the patient's ability to copy words, letters and syllables. It is important to observe the quality of the
Table 2
Results of Writing Investigations in Each Type of Agraphia
(Agraphia Names Derived from Corresponding Aphasia Type)

<table>
<thead>
<tr>
<th>Investigations</th>
<th>Acoustic Agraphia</th>
<th>Kines-</th>
<th>Kinetic Agraphia</th>
<th>Dynamic Agraphia</th>
<th>Semantic Agraphia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copy of letters and words</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Automatic writing</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Writing letters to dictation</td>
<td>—</td>
<td>—</td>
<td>+</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Writing words to dictation</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Written naming</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Agraphia increased by exclusion of spontaneous speech</td>
<td>+</td>
<td>+</td>
<td>—</td>
<td>—</td>
<td>+</td>
</tr>
</tbody>
</table>

(+ ) — intact.
(- ) — impaired.

copying — whether a slavish, mechanical rendition or a copy suggesting that the "mental trace" of the letter, syllable or word is preserved. Patients with semantic aphasia, because of marked visuo-spatial disturbances, exhibit notable difficulty with copying tasks. Execution of motor stereotypes, such as writing one's own signature, is assessed next. Patients with kinetic agraphia and frontal dynamic agraphia frequently perseverate on letters even in this test and patients with semantic aphasia have difficulty with letter formation. Patients with acoustic aphasia and kinesthetic agraphia may perform normally on this task. In cases where copying is impaired due to specific motor or visual-spatial deficits, cut-out letters may be used to assess letter identification and ordering.

Tests of dictation begin with letter dictation and proceed to syllables and words. Patients with efferent kinetic agraphia can frequently write individual letters to
dictation, a feature that distinguishes them from patients with other agraphic syndromes. Word writing is difficult for all aphasic patients, although the type of failure exhibited in each category of aphasia differs. Patients with efferent kinetic motor agraphia and frontal dynamic agraphia have prominent letter perseveration but only the frontal group manifests micrographia. Patients with semantic aphasia cannot construct individual letters or combine them into words. Patients with acoustic and kinesthetic aphasias also have difficulty writing to dictation: letter and syllable transpositions and omissions are more characteristic of the former.

Writing names of presented objects, giving written answers to queries and spontaneous narrative writing may exaggerate the abnormalities noted on writing to dictation and further clarify the characteristics of the writing disturbances. Inspection of errors in nominative and narrative writing may also elucidate abnormalities noted in the patient's oral naming and spontaneous speech. As these abilities all require preservation of capacities for acoustic analysis, synthesis of words and planning the "selective character" of what is written or spoken.

Luria noted that in his experience, lesions posterior to the Rolandic fissure produce agraphic disturbances in which exclusion of speech leads to a disintegration of writing. Conversely, with lesions located anterior to the Rolandic fissure, exclusion of speech has no deleterious effects on writing. Thus, acoustic, kinesthetic and semantic agraphia are all increased by eliminating simultaneous speech articulation, whereas efferent motor agraphia and frontal dynamic agraphia are not exaggerated by speech exclusion.

Writing Rehabilitation

Luria (1970) observed that writing disorders are seen in all the aphasias and reading and writing seldom recover spontaneously; but he believed that, with systematic retraining, improvement and occasionally complete recovery may occur. His strategies for rehabilitation were derived from his observations of the individual agraphias and from his view that reading and writing are based on auditory analysis and synthesis of speech. He emphasized the importance of rehearsing elementary steps in each strategy until the process becomes fully automatic. Eventually some degree of writing ability will be restored, although the mechanisms underlying the phoneme-to-grapheme translation may be unlike those utilized in the acquisition of writing in childhood.

In patients with acoustic and kinesthetic aphasia and agraphia, recognition of phonemes is lacking. This defect can be overcome by teaching the patient to rely on external cues that help to identify sounds, such as visualization of articulatory movements and palpation of the speech apparatus. These cues can then gradually be translated into the proper graphemes. Phoneme-to-grapheme translation can also be aided by using familiar ideograms to identify key sounds within words. For
example, the word “doll” could be reconstructed by using the familiar first sounds of the words “dog” and “light”.

Recovery from efferent motor agraphia depends on mastering the sequential schemata of words; this is best accomplished by having the patient practice using his knowledge of articulatory positions and of the relation of the sound to the grapheme to construct syllables. Writing is essentially transformed into an “articulatory dictation”. Dividing words into component parts (suffix, prefix, etc.) and filling in missing letters or syllables of incomplete words are useful rehabilitation exercises.

These rehabilitation techniques result in a radical reorganization of the process of writing by sound–letter analysis. The novel strategies gradually become automatized, but writing may never recover fully and attempts to write may continue to require considerable conscious attention. Writing rehabilitation is integrated with reading and oral-language therapy.

ALEXIA

Varieties of Alexia

Table 3 summarizes the principal types of alexia described by Luria (1970, 1980). He distinguished three types of optic alexia unassociated with aphasia. In the first, literal alexia, the patient is unable to read letters, confuses similar letters and cannot match letters written in different types of script. This type of alexia is a variant of visual agnosia (within the linguistic domain) and the patient is aided by kinesthetic input from tracing the letters. Patients with the second type of optic alexia, verbal alexia, can read individual letters but cannot synthesize them into words. Even ideographic reading of highly familiar letter symbols such as U.S.S.R. are read with difficulty and recognized only when reading them aloud allows auditory analysis. Luria classified verbal alexia as a form of simultaneous agnosia similar to that occurring in Balint’s syndrome; the patient’s visual attention is narrowed to one or at most a few letters and word and sentence reading are disrupted. The third form of optic alexia distinguished by Luria, hemialexia, is associated with right parieto-occipital lesions and neglect of left hemispace. Only the right side of horizontally presented words is read and vertically presented words are perceived and read normally.

Of the alexias associated with aphasic syndromes, the alexia associated with acoustic aphasia and resulting from a temporal lobe lesion is distinctive because of the preferential retention of ideographic reading. Familiar words are read easily, but unfamiliar words cannot be read either aloud or silently. Literal and phonemic analyses are profoundly disrupted and the patient relies heavily on recognition of visual patterns evoked by familiar letter combinations.
<table>
<thead>
<tr>
<th>Type of Alexia</th>
<th>Lesion site</th>
<th>Characteristics of the Alexia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literal alexia</td>
<td>Occipital lobe</td>
<td>Visuo-gnostic injury; cannot read letters; cannot match letters written in different styles</td>
</tr>
<tr>
<td>Verbal alexia</td>
<td>Occipital lobe</td>
<td>Visuo-gnostic injury; can read letters but not words; aided by reading aloud</td>
</tr>
<tr>
<td>Alexia with left-sided</td>
<td>Right-sided parieto-occipital</td>
<td>Only the right side of words are read; vertical words are read normally</td>
</tr>
<tr>
<td>neglect</td>
<td>region</td>
<td></td>
</tr>
<tr>
<td>Alexia with acoustic</td>
<td>Temporal lobe</td>
<td>Cannot read letters or words; ideographic reading retained</td>
</tr>
<tr>
<td>aphasia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alexia with afferent</td>
<td>Rolandic operculum</td>
<td>Loss of letter meaning; not helped by reading aloud; ideographic reading preserved</td>
</tr>
<tr>
<td>motor aphasia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alexia with efferent</td>
<td>Inferior premotor</td>
<td>Can read letters; cannot read syllables or words</td>
</tr>
<tr>
<td>motor aphasia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alexia with frontal</td>
<td>Inferior prefrontal area</td>
<td>Reading consists mostly of guesses based on a few recognized letters</td>
</tr>
<tr>
<td>dynamic aphasia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alexia with semantic</td>
<td>Inferior parietal area</td>
<td>May have verbal alexia</td>
</tr>
<tr>
<td>aphasia</td>
<td></td>
<td>(described above)</td>
</tr>
</tbody>
</table>

Afferent motor aphasia is accompanied by an alexia which is similar to that seen in acoustic aphasia. However, in addition to disturbed letter and phoneme analysis and retained ideographic reading, the patient with afferent motor aphasia mis-articulates the few letters he recognizes. Unfamiliar word reading suffers from mispronunciations and phonemic substitutions.
Patients with efferent motor aphasia can read letters without difficulty but cannot synthesize them into syllabic or lexical units. The patient is aware of the difficulties and frequently guesses at the word based on recognition of a few letters. Similarly, lesions of the prefrontal cortex produce frontal dynamic aphasia and an alexia characterized by guesses, uncontrolled associations and perseverations. The breakdown of verbal regulation of motor processes and failure to compare one's end result with one's intention underlie this type of alexia. In some cases of semantic aphasia, the inferior parietal lesion may give rise to an associated verbal alexia (described above).

Investigation of Reading

The examiner first determines visual acuity, presence of visual field defects or neglect and abnormalities of ocular movements. The examination of reading begins with the recognition of individual letters. The patient is asked to read letters aloud, to match letters written in different scripts, to say words beginning with selected letters and to read letters written as mirror images. Letter reading can be further tested by asking the patient to read letters hatched over with additional lines. The degree to which reading is facilitated by kinesthetic tracing should also be noted.

Simple and complex syllable reading is assessed next. The patient is asked to read easy and difficult letter combinations and the errors committed are carefully noted. Narrowing of visual attention to single letters suggests a verbal alexia, whereas errors in articulation are most consistent with afferent motor aphasia with alexia.

Word reading is the next step in the investigation. Nonsense words as well as familiar and unfamiliar words are tested. Familiar words may be read ideographically in acoustic aphasia and afferent motor aphasia, while guesses characterize the reading of efferent motor aphasia and frontal dynamic aphasia. Word reading may be made more difficult by presenting words in which letters have been omitted or transposed. Reading silently may be assessed by presenting pictorial response choices. Ideographic reading is distinguished by preserved comprehension of familiar words but an inability to read the word aloud, whereas, unfamiliar words cannot be read aloud or silently with comprehension.

The final step of reading evaluation involves the reading of phrases and sentences. Unusual sentences should be tested to detect guessing by patients with frontal lesions. Eye movements and any tendency to lose one's place while reading are also noted. For all neuropsychological tests Luria cautioned the examiner to note the role of inhibitory as well as active processes, to observe signs of fatigue and to be sensitive about the "general tone to cortical activity".
Reading Rehabilitation

Luria's methods for restoring reading stemmed directly from observations of each type of alexia (Luria 1970). Patients with optic alexia resulting from occipital injuries were encouraged to copy letters, match letters written in different graphic styles, use kinesthetic reading as an aid and learn which letters correspond to specific articulatory positions.

Luria discouraged the use of ideographic reading and suggested that patients with acoustic aphasia and afferent motor aphasia should not rely on ideographic word recognition but should work first on phonemic analysis and then on re-establishing letter reading. Afferent motor aphasics were instructed to begin reading restoration by reading aloud to aid in reconstructing articulatory schemata. Later, reading in a whispered voice and, finally, reading silently were gradually introduced.

Patients with efferent motor aphasia require restoration of word analysis with special emphasis on suffixes, prefixes, phoneme order and inflectional alterations. Cinematic reading -- reading through a small hole to help isolate individual words -- was found to be particularly useful in this disorder.

READING AND WRITING IN LURIA'S NEURODYNAMIC CONTEXT

Luria's treatment of acquired reading and writing disorders following brain damage relied heavily on his general theoretical approach to the relationship between human abilities and brain function. Several cardinal principles characterize this approach. He emphasized that all abilities have an ontogenetic, phylogenetic and cultural history that influence their expression in normal and brain-injured individuals. He believed that the brain acts as a whole -- a unified neurodynamic entity -- but that individual lesions disrupt brain function in unique and clinically identifiable ways. He concluded that many cortical zones must be responsible for a complex function such as writing or reading and that these zones change with learning. He observed that, during development, linguistic processes become automatized; the degree of automation achieved is related to the extent to which the skill is used in each individual and some of the variability in severity noted in different patients with similar lesions may be partially accounted for by the patient's premorbid experience, training and sophistication.

In Luria's model of brain/behavior relations, many analyzers (i.e. auditory, visual, phonetic) were organized into functional constellations, each mediating a complex skill (i.e. speech, writing, reading). He rejected psychomorphologic localizationist theories, saying that these overlooked the systemic effects of focal lesions; he also rejected noetic holistic themes, which he believed to be in conflict.
with facts regarding local specialization of cerebral regions. Luria's neurodynamic approach substituted analyzers — a concept derived from Pavlov — for centers and emphasized that each analyzer constitutes but one portion of a larger functional whole. He felt it was useless to look for a reading or writing “center”. Instead, the patient's symptoms reflect losses associated with a specific analyzer as well as the compensatory activity of the remaining neurodynamic organization. In this way several varieties of alexia and agraphia can be distinguished, each corresponding to disruption of specific functions and preservation of others.

Luria also emphasized that disruptions of psychological abilities such as writing or reading are accompanied by deficits in other abilities. Cerebral areas mediate multiple functions so that injury to a given area will be manifested in several psychological functions. The best example of this principle is the disruption of reading and writing produced by a prefrontal lesion. Luria postulated that breakdown in “kinetic synthesis” — in sequential chaining of behavior — is the basis of many behavioral alterations noted after premotor cortical damage. Likewise, prefrontal alexia and agraphia reflect the patient's general inability to synthesize units into integrated sequences and to use verbal abilities to mediate other functions.

LURIA'S APPROACH TO READING AND WRITING IN A CONTEMPORARY CONTEXT

Luria's concepts presaged many contemporary developments concerning the neuropsychology of writing and reading. Within the domain of writing, Luria was among the first to suggest a hierarchy of stages from the motivational to the linguistic to the mechanical. Writing may be disrupted at any of these levels.

The agraphias emphasized by Luria and associated with aphasias arise from disruption of phonological and semantic processes. Similar syndromes have been described and expanded by contemporary investigators. For example, the inability to write pronounceable non-words alongside preserved ability to write real words has been described by Roeltgen et al. (1983) and deep agraphia, the ability to write familiar but not unfamiliar words and the tendency to make semantic substitutions, was investigated by Bub and Kertesz (1982). Problems with execution of the written code recognized in current descriptions include “apraxic agraphia” (Margolin and Wing 1983; Baxter and Warrington 1986) and micrographia (Benson and Cummins 1985). Luria did not implicate the right hemisphere in overlearned writing and reading, as Coltheart (1983), Marshall (1976) and Simertnitskaya (1974) have done.

Luria also made significant contributions to the understanding of the alexias.
Particularly striking was his early observation that ideographic reading may be maintained even when analytical reading routes are disrupted. He accounted for this phenomenon by ascribing it to preserved abilities of brain regions outside the visual analyzer, but did not attempt further localization. Recently this phenomenon has come under intensive scrutiny and has been identified with right hemispheric reading (Marshall and Newcombe 1966; Coltheart 1980, 1983). Luria recorded many of the elements now recognized to be part of the deep dyslexia syndrome, including the key tendency to make semantic substitutions (Marshall 1976). He also described a patient in whom ideographic reading abilities diminished as analytic reading recovered, an observation suggesting an antagonism between these two reading strategies that has since been confirmed in other cases (Landis et al. 1980, 1983).

Another area of reading anticipated by Luria involves the reading abnormalities associated with frontal lobe lesions. Alexia with agraphia and alexia without agraphia were both described in the late 1800s by Dejerine, whereas an alexia associated with frontal lobe dysfunction was not widely known until Benson’s description of alexia with Broca’s aphasia (Benson 1977, 1985). Luria, however, had observed and described reading disturbances associated with frontal lobe lesions. He noted alexia in patients with both frontal dynamic aphasia and efferent motor aphasia and suggested that the reading as well as the oral language abnormalities were reflections of disruption of fundamental functions of the frontal lobes, such as verbal regulation of behavior and comparison of action products with action plans. He emphasized that alexia and agraphia associated with frontal lobe disturbances were manifestations of a more generalized disorder and were not isolated deficits as may occur with more posterior lesions. Similar conclusions have been reached in contemporary investigations of human frontal lobe function (Stuss and Benson 1984).

Luria also foresaw the need to design syndrome-specific treatment strategies. As described above he suggested specific means for approaching each type of alexia and agraphia. In some cases, school-like exercises were prescribed, whereas in others such therapies were recognized to be untenable and alternate methods developed. In this way he anticipated current attempts to develop specific treatments such as melodic intonation therapy for Broca’s aphasia or visual communication therapy for global aphasia (Sparks et al. 1974; Gardner et al. 1976).

Luria’s linguistic sophistication was as impressive as his neurologic acumen. Throughout his discussions of alexia and agraphia, he adopted tenets of modern structural linguistics. For example, he distinguished underlying grammatical knowledge or language competence, from performance or the physical realization of that knowledge. He utilized the concept that a unit type (e.g. phoneme or grapheme) is an abstraction, distinct from its instantiation as a sound or letter (i.e.
allophone or allograph). He was aware that speech sounds merge and vary with phonetic environment; so that the listener must "extract" phonemes as part of an active process of acoustic analysis.

Another linguistic notion employed to advantage by Luria is that of phonetic features. Deficits in "sound analysis and synthesis" ability, underlying most reading and writing disorders, can be seen in the patient's tendency to substitute "homorganic sounds" — sounds related by a single phonetic feature (e.g. voicing p as b). He observed such featural errors in afferent motor aphasia and noted that they lead to a specific type of reading deficit.

Luria anticipated recently developed "top-down" models of reading comprehension, whereby the reader/listener "forms a hypothesis" about the meaning of incoming speech in an active rather than a passive process, constantly generating an "expected meaning" based on several levels of knowledge (e.g. phonological, lexical, syntactic and semantic). This is in contrast to behaviorist models that postulate a phone-by-phone, word-by-word chained procedure in comprehension.

Luria developed a frankly mentalistic terminology befitting the psychological concepts he attempted to describe. He was grappling with difficult and important matters in cognition, such as the role of meaningfulness, familiarity and skill, while striving to acknowledge levels of processing that are not directly observable, such as "mental traces", "motor programs" and "graphemic units". His definitions sometimes lack clear operational definitions, but his theoretical structure is well grounded in rigorous neuropsychological testing procedures and clinical observations. Our contemporary perspective makes it clear that Luria's concepts, derived from thorough clinical observation and deductive categorization without reliance on mechanistic or narrow behavioralistic paradigms, anticipated many current developments in neuropsychology and behavioral neurology. His observations regarding alexia and agraphia serve as examples of his neurodynamic model and demonstrate the enduring strengths of his approach.

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NOTES

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