SSW REPORTS

A PEEK AT THE BRAIN THRU THE EARS

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THE SSW TEST: A TEN MINUTE LOOK AT THE CNS THROUGH THE EARS *

Jack Katz and Paula S. Smith

There are two major applications of the SSW. It is used in (1) locating brain abnormalities resulting from tumors, strokes or degenerative conditions, and (2) the evaluation of auditory processing problems, associated with learning and other disabilities.

Support for the identification-localization functions of the SSW came from several sources employing a variety of pathological groups. These include temporal lobectomy {1}, tumor {2,3}, stroke {4}, commissurotomy {5}, and degenerative disorders, such as Alzheimer's disease {6}.

In the late '60's and early '70's, attention turned to the auditory problems in those with learning difficulties {7,8}. The categorization that was used for site-of-lesion testing was not appropriate nor sufficiently sensitive to evaluate the learning disabled. A statistical standard was introduced and recently updated {9,10}.

SSW FINDINGS IN SITE-OF-LESION CASES

The two major sources of information for locating cerebral lesions are (1) the severity of the score and (2) response bias. The severity of the score helps to differentiate lesions to the auditory reception (AR) centers versus lesions that spare these regions (NAR). Response bias has been found to be most useful in locating impairments in various parts of the cerebrum based on asymmetrical responses that are noted among the 8CNs.

Posterior Temporal (PT) Lesions

Auditory reception and auditory association . The AR center (primarily Broadmann's area 41) is embedded in Heschl's gyrus on the opercular surface of the middle-posterior portion of the temporal lobes {11}. They receive input directly from the auditory brainstem. The auditory cortex (primarily Broadmann's area 22) includes the lateral surface of the middle and posterior portions

of the superior gyrus of each temporal lobe. Each receives input from the AR center for further analysis. Luria {12}, points out that the auditory cortex serves as the phonemic zone of the brain and that patients with lesions of the phonemic zone tended to miss the endings of (Russian) words. Similarly, Burns and Canter {13} noted posterior temporal cases have more difficulty in comprehending the ends of sentences than the beginnings.

Posterior temporal cases are somewhat slow in reponding to speech and require even more time when the material is longer or complex. Damage to the auditory cortex on the left side can be expected to produce receptive difficulties for speech sounds as well as language (i.e., Wernike's aphasia). Such individuals may continue to need additional time to sort out their vague perceptions, even after recovery from the primary aphasic symptoms. Recently, Blumstein {14} presented supporting evidence for the slow processing in Wernicke's aphasics. She was able to demonstrate improved performance using time expanded speech.

Indications from the SSW score. For purposes of illustration, a group of 110 cases with well localized lesions were studied (70 were from previously studies and 40 cases were newly published). Figure 1 shows the results for the 42 cases with lesions of the right or left AR center. Means and standard deviations for the four Condtions are displayed separtely for those with R-and L-hemisphere invlovement. Moderate or severe SSW scores are typically obtained in AR cases. Forty-one of those with AR lesions had moderate or severe C-SSW scores. The contralateral effect is seen more clearly in the R-hemisphere cases, as those with L-sided damage also had depressed performance in the LC Condition. These results may be compared with the data for 46 NAR cases (see Figure 2). The latter subjects had lesions of the cerebrum which did not involve Heschl's gyrus. In contrast to the AR group, only 11% of the NAR cases had moderate C-SSW scores and none had a severe score.

Indications from response bias. Additional diagnostic support for involvement of the posterior temporal region can be obtained from response bias information. The Order Effect L/H has been recognized as a common feature when there is a lesion of the PT lobe {15,16}. The finding of significantly more errors at the endings of test itmes than the beginnings was recently replicated in a CT scan cross-validation study {17}.

Of 110 verified cases, the incidence of Order Effect L/H was compared for the AR and NAR cases. Forty-three percent of the AR cases showed this PT response bias, whereas none of the NARs demonstrated it. Thus, the posterior Order Effect clearly differentiated ARs from NARs.

To summarize, the posterior portion of the temporal lobe is associated with phonemic identification and phonemic memory. SSW findings with these lesions, in either hemisphere, are exemplified by moderate or severe C-SSW scores. The major portion of the errors are found in the ear opposite the lesion, especially on the competing

portion of the items. In addition, PT response bias is frequently noted. The Order Effect L/H is a strong indication of AR involvement in cerebral lesion cases. A person's slow or imprecise processing of speech could contribute to errors on the second halves of itmes.

Frontal and Anterior Temporal (AC) Lesions

Behavioral characteristics. The frontal lobe and anterior temporal region of the brain serve some unique but often similar or related behavioral functions. In the frontal lobe, the prefrontal cortex is the most anterior portion. Among other functions, it appears to provide for a differential response to each of two stimuli {18}. Broca's area, in the inferior frontal convolution, is the major expressive language center. It is located in the language-dominant hemisphere, usually the left {19}.

The anterior temporal region contains two important deep structures, the hippocampus and the amygdala. The hippocampus runs the length of the temporal lobe, medially and inferiorly. It is well-recognized as a vital memory processing region {20, 21, 22}. The amygdala is situated superiorly at the anterior end of the hippocampus. It is associated with memory processing and behavior. Two recent animal studies help to elucidate its complex functions. The amygdala appears to have a direct auditory connection from the medial geniculate body. When this pathway is lesioned, there is a reduced bodily response to conditioned aversive stimuli; however, the response to the unconditioned stimulus remains unchanged {23}. With the introduciton of morepinephrine into the amygdala, avoidance behavior to noxious stimuli may not be learned {24}.

A wide vaiety of symptoms have been noted with damage to the anterior temporal or frontal regions. Struss and Benson {25} list nine behavioral characteristics concomitant with frontal lobe lesions. They are: motor impairment (hypo- or hyperkinetic), sensory and perceptual dysfuntion (fixaton on initial feature), attentional difficulites (inability to inhibit distractions), abnormal awareness (sensory neglect), perseveration (although not exclusively a frontal sign), sequence disturbances, memory failure (stored information that is not readily accessible), personality changes (unrestrained, tactless, callous lack of concern, obstinate, childish), and intellectual changes (unimaginative, ineffective, careless working habits). McAllister and Price {26} note that because of the similarities in behavior, frontal lobe lesion cases may be misdiagnosed as schizophrenics.

Another important characteristic of those with anterior temporal lobe lesions is poor listening ability in a background of noise. A reduced "cocktail party" skill was noted in patients who had anterior temporal lobectomies {27}. This may be associated with an impairment of the "temporal lobe enhancement mechnanism" that is thought to enable the listener to increase the prominence of a selected sound or, the salience of a particular voice {28}.

Indications from response bias. The Order Effect H/L is one

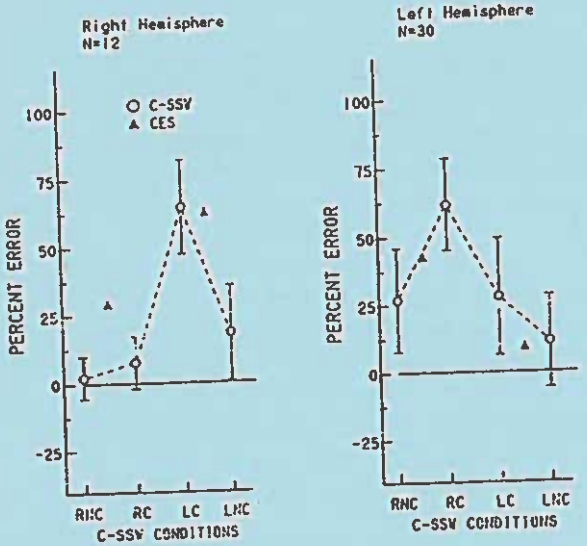

Figure 1

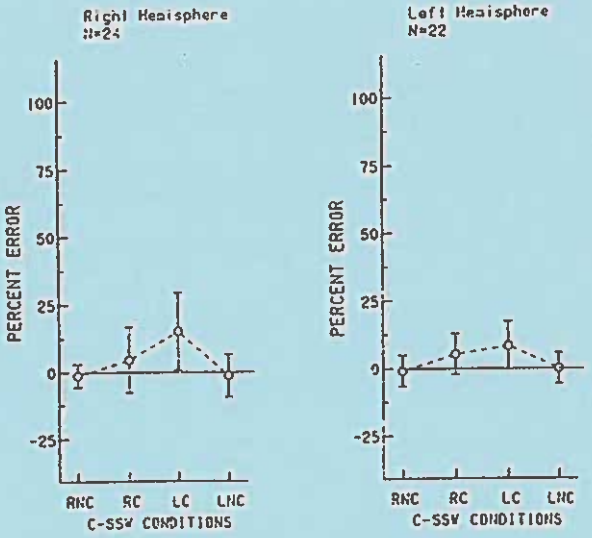

Figure 2

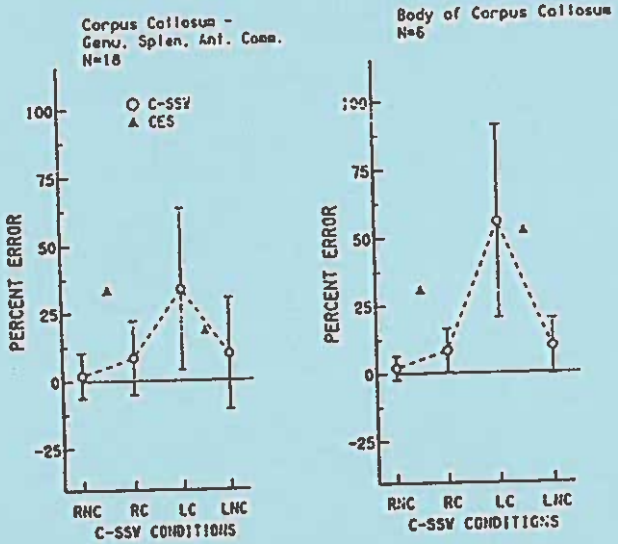

Figure 3

Figure 1 shows the performance of patients with lesions of the auditory reception center on the 4 C-SSW Conditions (o) and CES findings for the right and left ears (A). Data for right and left hemisphere cases are presented separately.

Figure 2 presents C-SSW data for cases with lesions to the cerebrum which spare the auditory reception centers (and were not diagnosed as having specific corpus callosum involvement). Data for right and left hemisphere cases are presented separately.

Figure 3 provides comparable data for cases with lesions to commissural pathways of the brain. On the left are the patients with lesions of the genu and splenium of the corpus callosum as well as the anterior commissure. On the right are the cases with lesions of the body of the corpus callosum. The C-SSW and CES data are shown.

of the three response biases that is associated with Anterior cerebral (AC) lesions. Among the AC cases, 38% had the Order Effect H/L. In the AR group, 22% had this as well. This is not felt to be evidence of false positive results. Rather, all AR cases had involvement outside the small AR region. Damage usually extended anteriorly from Heschl's gyrus (e.g., stroke of temporal branches of the middle cerebral artery). It is hypothesized that the greater number of errors on the first spondee of the items, as compared to the second, relates to poor memory. It is therefore not surprising that a group that has poor recall and difficulty in delayed-response tasks would have this pattern of errors.

In summary, AC cases tend to have limited skills for listening in noise and have fewer errors than PT patients, with performance falling into the normal or mild C-SSW category. Over 1/3 of them demonstrated an anterior Order Effect, which is just one of the three AC indicators. A rapidly fading memory could contribute to the poorer performance noted at the beginning of items.

Temporal-parietal Occipital (TPO) Lesions

The point on the cortex at which the temporal, parietal and occipital lobes meet is not clearly marked. However, the functional contributions of this area are considerable. Just as geographical junctions between land masses have great strategic significance, this region of the brain, with its unique location, assumes important intercommunication funcitons.

The angular gyrus of the temporo-parietal occipital (TPO) region is strategically situated between the auditory cortex of the temporal lobe and the visual cortex of the occipital lobe. It has long been recognized as a vital auditory-visual integration center {29}. In the L-hemishpere, it is situated in close proximity to the language center, planum temporale {30}. In the R-hemisphere, the TPO area is adjacent to the visual-spatial region of the parietal lobe. By use of the splenium (the posterior portion) of the corpus callosum, auditory-lingustic information from the L-hemishphere can be integrated with the visual-spatial input of the R-hemisphere.

Dyslexia is thought to result from lesions of the TPO region {31} and/or the corpus callosum {32}. In particular, the inferior portion of the splenium has been implicated in pure alexia (i.e., without agraphia) {33,34}. It is interesting to note that the anterior and middle sections of the corpus callosum are thought to be associated with schizophrenia {35} and depression {36}.

Left ear SSW peak. The most common SSW characteristic of those with angular gyrus or commissural pathway lesions is a significant LC peak. We have consistently seen this left-sided pattern in angular gyrus cases (except in a small percentage of left handers) and in all of our corpus callosum and anterior commissure cases that have significant SSW scores (see Figure 3).

Interpretations from response bias. On the SSW, the Type A pattern is associated with angular gyrus and/or corpus callosum lesions {37}. Type A bias has been noted in one-third of corpus callosum cases {38}. A similar percentage has been found in anterior commissure patients. Unfortunately, the Type A pattern is not a strong localizing sign because it may be found in cases with lesions in a variety of cerebral, cerebellar and brainstem regions. With knowledge of a severe reading and/or spelling disorder and a Type A pattern, one may assume that the lesion, if any, invloves the angular gyrus and/or the splenium of the corpus callosum.

To summarize, TPO (and/or posterior corpus callosum) lesions produce severe reading and spelling problems. Fewer learning problems but a greater number of psychiatric disorders are noted with lesions of the anterior or middle portion of the coprus callosum.

SITE-OF-DYSFUNCTION SIGNS IN CASES WITH AUDITORY PROCESSING PROBLEMS

Three Major Auditory Processing Categories

PT signs - the Auditory Decoding group. In children who are referred because of learning disabilities, posterior temporal response bias is closely associated with RC SSW peaks and delayed responses. They show evidence of faulty phonemic processing on such tests as Phonemic Sythesis and not suprisingly, mild to moderately depressed performance on speech-in-noise tasks.

AC signs- the Auditory Tolerance-Fading Memory Group. Anterior cerbral response bias has been noted in LD cases. On the SSW, they are the ones who are most likely to have unusually quick responses to items and get tongue twisted in giving their answers. Delays in responding often result in errors. Despite instruction and reinstruction, they respond to the introductory phrase on the SSW as though they cannot inhibit the reaction. These individuals tend to be highly distractable and display severe speech-in-noise difficulty in everyday listening situations.

TPO signs - the Auditory Integration group. Type A patterns, or sharp SSW peaks in the LC condition, are commonly associated with poor integration (presumably interhemispheric transfer and combining the information from auditory and visual modalities). In this group, we see especially long delays in responding. Nevertheless, the eventual answer is typically correct and appears effortless despite the extremely long pause.

Test scores alone may not differentiate those with TPO-type integration difficulties from others who appear to have involvement of the middle/anterior portions of the corpus callosum or anterior commissure. Acedemically, the TPO group has severe reading and spelling problems and are often labeled "dyslexic". They perform poorly in auditory-visual integration tasks and in phonics.

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