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Multiple Response to Sound in Dysfunctional Children[1]

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Methods and findings derived from over a decade of linguistic-kinesic microanalysis of sound films of human behavior were appled to the analysis of sound films of 25 dysfunctional children. Of the children, 17 were markedly dysfunctional (autistic-like) while 8 had milder reading problems. All of these children appeared to respond to sound more than once: when it actually occurred and again after a delay ranging from a fraction of a second up to a full second, depending on the child. Most of the children did not seem to actually hear the sound more than once; however, there is some indication that a few children may have done so. Evidence was also found suggesting a continuum from the longer delay of autistic-like children to the briefer delay of children with reading problems.

> The order and connection of ideas is the same as the order and connection of things.
>
> —Spinoza, 1673

This paper presents some preliminary results of microkinesic or linguistic-kinesic sound-film analysis of autistic-like and dysfunctional child behavior. Microanalysis permits a study of the nature of the response of the organism to sound at rates which are too fast for the naked eye. In this regard, an addition to the concept of "response" is presented, postulating an almost immediate linkage of the organism with incoming signals. This view of response time provides a new

[1] The microanalysis of sound films of autistic-like behavior was begun several years ago in Pittsburgh, Pennsylvania. At that time, Drs. William Ogston and Janos Schossberger were companions in the research. The author is also deeply indebted to the vision of Dr. Henry W. Brosin, who encouraged and supported the development of microkinesic analysis.

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perspective for the intensive study of both normal and autistic-like behaviors. The term "autistic-like" is used since it has not been ascertained that all children studied meet Rimland's (1964) criteria for the diagnosis of autism. In his book, Rimland also speculates about the possibility of delayed audition in autism. In order to gain a greater understanding of pathological behavior, it is often necessary to obtain more information about normal behavior. Unfortunately, the organization of normal behavior has been systematically microanalyzed only within the past decade. This has been done primarily in the area of the study of body motion or kinesics. It is essential to have trustworthy "units" in terms of which normal behavior and interaction can be analyzed, for this provides a basis for comparison with pathological behavior. Findings and techniques from this emerging discipline of kinesics (particularly microkinesics) have been utilized in studying films of the behavior of dysfunctional children. Kinesics is, in general, the study of body motion or nonverbal behavior, an important aspect being the cultural usages of the body in both movement and posture. It should, perhaps, more properly be called "linguistics-kinesics" for linguistics is also an important aspect of the study of body motion. Since this is a newly emerging discipline, some of the basic methods and findings reported in earlier publications need to be briefly reviewed to provide a background for readers unfamiliar with the field.

METHOD

There is a very rough analogy between the development of kinesics and the development of linguistics as disciplines. Initially, the linguist faced the problem of segmenting language into its component elements. Methods, decisional criteria, and other logical procedures are developed concomitantly with the analysis of language into its several "levels." It took many years for the various "hierarchic" orders within language to be clarified. In the following paragraphs, I will attempt to present the results of a similar segmentation of the kinesic domain into "units" and their "hierarchic" ordering as this is tentatively understood at the present time. In the present context, a unit is not conceived as a discrete or atomistic isolate, but as a distinguishable, recurring form of order within the organized processes of behavior. Analysis begins with organized, communicational processes, segments them into discoverable patterns of ordered relationships, and concludes with statements about the structure of that organization. Initially, the observer of a sound film of human interaction is confronted by a complex, ongoing flux of events where many things are occurring simultaneously at many levels. A method analogous to that of the ethologist was adopted. The ethologist, for example, will spend hours observing the behavior of a flock of gulls in their natural environment. He must identify individual members as well as pairs, studying their interactions for repetitive forms which reveal the recurring patterns of relationship within the gull world. He is, to a certain extent, exploring an unknown universe (Tinbergen, 1960).

It has proven useful to proceed as if nonverbal behavior were also an unknown universe to some extent. A film of human interaction can be viewed again and again, many thousand times if need be. Such intensive viewing suggested that the direction and speed of movement of the body parts of communicants might provide an initial descriptive frame to begin the analysis of behavior. In this sense, the movement of the body parts can be conceived as "functionally" discrete, although not discrete in actuality. For example, the movement of the forearm can be described in terms of changes at the elbow joint, but the forearm is not separate or isolated from the other parts of the body. As part of the total organism, it participates in many of the regularities that govern the behavior of the total organism. All detected movements of these body parts, from head to feet, including eyes, brows, and mouth, are carefully analyzed frame by frame. A modified 16-mm Bell and Howell time motion analyzer is used (Condon, 1970). This permits a manual scanning of the film, one frame at a time or across a series of frames, including variation of the sizes of the series of frames so contrasted. Each frame is numbered to permit identification (Van Vlack, 1966). Equipment has been constructed which enables the investigator to segment the sound track on the film down to 1 frame, commensurate with body motion, e.g., phone types, syllables, words, and inanimate sounds. This creates a basis for the comparison of speech and body motion events at the same level. The sound film stores the historical process of the speech and body motion of the interactants. The above segmental procedures permit an analysis of this now "frozen" history by repetitions of it or selected parts of it over and over, across varying dimensions, and from various perspectives, including the possibility of correcting previous impressions about what might constitute segments.

The body joints with their modes of extension–flexion, adduction–abduction, pronation–supination, etc., constitute the primary, descriptive focus for

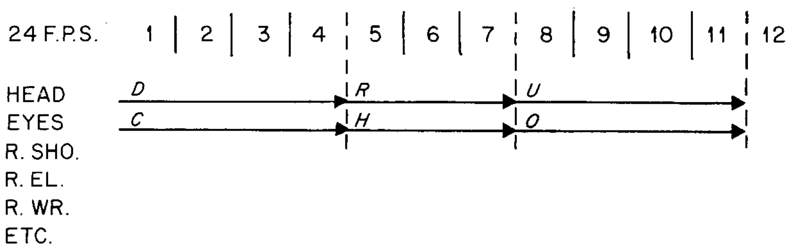

Fig. 1. Example of kinesic frame-by-frame analysis. Symbols for all figures: R, right; D, down; Q, incline; B, back; U, up; S, supinate; F, flex or forward (depending on body part); P, pronate; E, extend; AD, adduct; AB, abduct; L, left; C, close; O, open; H, hold or no movement; RI, rotate in; RO, rotate out; ↗, wrist movement in direction of little finger; suffixes: vs, very slight; s, slight; f, fast; vf, very fast.

identifying the frame numbers marking points of body motion change. To illustrate, the head may go down for 4 frames, right for 3 frames, and then up for 4 frames. While this is happening, an eye blink may also be occurring. When the eye begins to close, when it is shut and for how long, when it opens, and the point when it stops opening can be examined frame by frame. Thus the movements of parts of the body can be microscopically compared to each other as well as to speech. Figure 1 illustrates the flow notation which describes this sequence of changes, using lines for frames during which movement in a given direction is sustained and arrow points at the frame in which termination of movement or change in direction of movement occurs. This results, to emphasize, in a microflow transcription of the organism's complex patterns of body part changes over time, permitting an organizational analysis of the relationships of change of the body parts to each other and to the articulate segments of speech.

As a person speaks, there are most often several body parts moving together simultaneously. These cooccurring movements posed a difficult problem for segmentation until a primary form of order was discovered to be a basic characteristic of the movement of these body parts in relation to each other and to speech. In other words, movement could not be analyzed into discrete segments of which it could then be said to be composed because several body parts were almost always moving simultaneously. However, a precise pattern of order was discovered to be sustained between these simultaneously moving parts. It is this order which is a basic characteristic of behavior, not the order of specific body parts (although these too have pattern from other perspectives). This primary form of order between moving body parts results in what effectively amounts to the required "units" of behavior in terms of which normal behavior and interaction can be analyzed as a basis for comparison with pathological behavior. In essence, a unit of behavior has been observed to exist as a form of order in the relationships these simultaneously moving body parts sustain with each other (a regularity of form of organization); these units do not consist of behavior reduced to discrete elements. The postulate is that at the microlevel behavior emerges as quanta which are minimal forms of organization. Such organization appears to characterize all human behavior (and perhaps nervous systems in general) and will be described more fully below. These quanta or bundles of movement have been called "process units" to emphasize their organizational character in contrast to a discrete conception of units. Behavior is postulated to be composed of multiple, integrated levels of organizations. Individual behavior appears to occur as a "rhythm hierarchy" where suborganizations are unified aspects of wider and wider, circumscribing organizations. Figure 2 illustrates the "process units" and the syllabic and word dimensions of the rhythm hierarchy in speaker behavior. The occurrence of the word "ask" (which lasts approximately 1/5 second) in the phrase "to ask you" is examined in microdetail. It is from a

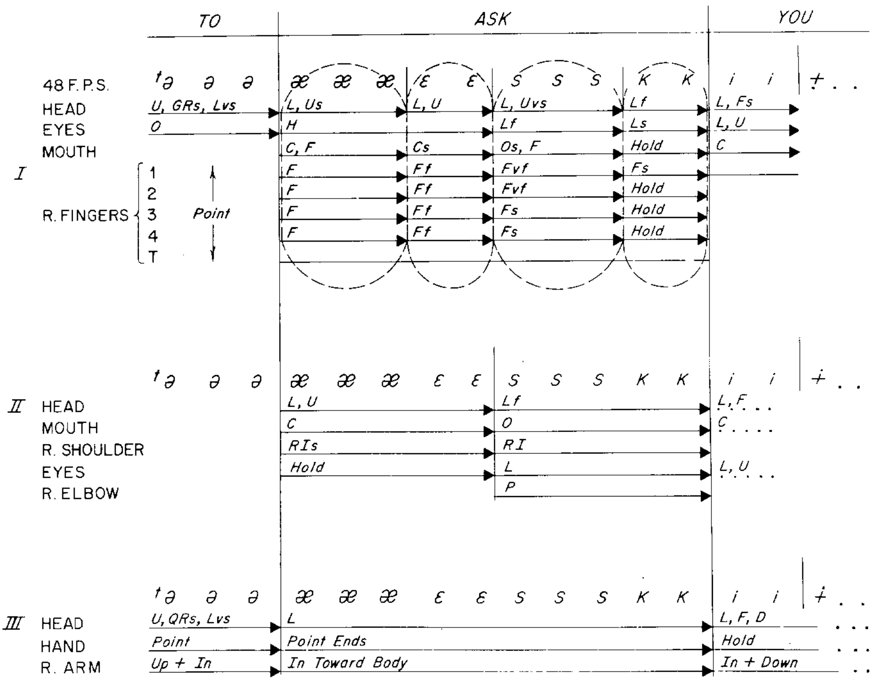

Fig. 2. Microdetail of rhythm hierarchy with process units circled. This is from the speaker in a dyadic interaction.

dyadic interaction between 2 adult males. "Ask" is analyzable into 4 speech sounds (phones): /æ/, lasting 3/48 second; /ɛ/, lasting 2/48 second; /S/, lasting 3/48 second; and /k/; lasting 2/48 second.

"Process Units"

The body moves in 4 clusters of patterned change which are isomorphic with the 4 linguistic features into which the word "ask" is analyzable. To illustrate from Figure 2, across the 3/48-second duration of /æææ/ the head moves left and up slightly (L, Us), while the eyes hold (H), while the mouth closes and comes forward (C, F), while the four fingers begin to flex (F), while the right shoulder rotates inward slightly (R, Is). All of these movements sustain their relationships to each other during this 3/48 second. No other body parts can be detected moving. These are the most minimally detectable changes during that interval; that is, each is seen as a smooth, unitary flow of movement with no detectable internal changes. This gives rise to a "process unit" (composed of these body elements sustaining a relationship of different directions and speeds of movement together) as itself an organized, behavioral form with respect to the total organism (Condon and Ogston, 1967). Organized behavior is not "more than" or "composed of" these moving body parts sustaining together, it is *in* all of them. Behavior is *the* while that is being sustained while the body parts are sustaining together. All these "whilings" bracketed in an ongoing unity *is* behavior. This paper thus also presents a method for the analysis and interpretation of organization as organization rather than as parts composing a whole. Consequently, some forms of pathology are interpreted as breakdowns of organization. The process unit (as such sustained "whilings") contrasts with preceding and following similarly formed process units. Several of these process units are circled in Figure 2 for illustration. Behavior is composed of the serial emergence of such organized process units or quantal "forms of movement" at the minimal level.

Across /εε/, which lasts 2/48 second, the head continues left but the upward aspect is now more marked (L, U), while the mouth closes slightly (Cs), while the four fingers now flex fast (Ff) and the right shoulder continues rotating inwardly slightly (RIs). These body movements maintain these new forms of movement together, forming another process unit which differs from the preceding. Similarly contrasting process units occur isomorphically with /sss/ and /kk/. Thus it is more accurate to speak of linguistic-kinesic, where the hyphen signifies behavioral inseparability, rather than linguistic *and* kinesic.

Self-Synchrony

Body motion is integrally organized with speech across many dimensions, however, not just at this microlevel. It is the total unified organism which has linguistic-kinesic behavior. These further "hierarchic" orderings between speech and body motion reflect that organizational integrity. The word "ask" in Figure 2 has body motion forms occurring isomorphically with /æææεε/ and /ssskk/ and also across the total word as well. Rhythm or time must also be seen as a fundamental aspect of the organization of behavior and not as something

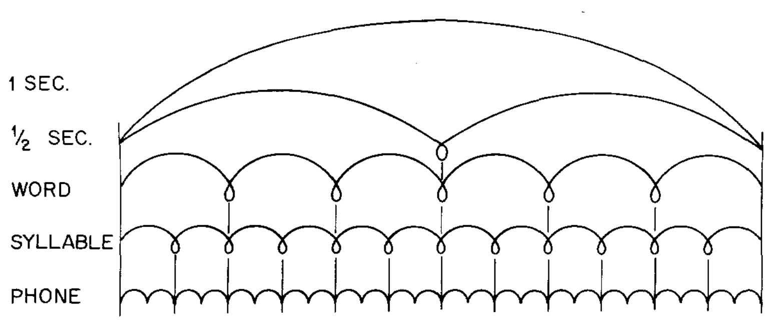

Fig. 3. Schema of the rhythm hierarchy in speaker behavior.

added to it. Speaker behavior occurs through a precisely integrated rhythm hierarchy, previously mentioned, which appears to be a basic carrier form for the segmental features of both speech and body motion (Condon, 1973). The word "hierarchy" is used very reluctantly, since for many people it connotes discrete bits contained in ever higher discrete levels. The rhythm hierarchy is analyzable into (1) process units (which correspond roughly to the phones), (2) syllables, (3) words, (4) a ½-second cycle, and (5) a 1-second cycle. The 1-second cycle seems to be a basic form in speaker rhythm. Figure 3 provides an illustrative schema of the rhythm hierarchy.

Interactional Synchrony

Further intensive microanalyses of sound film of human interaction have revealed a very startling phenomenon. *Listeners* were observed to move in precise shared synchrony with the speaker's speech. This appears to be a form of entrainment since there is no discernible lag even at 1/48 second. This has been called interactional synchrony. It also appears to be a universal characteristic of human communication, and perhaps characterizes much of animal behavior in general. Communication is thus like a dance, with everyone engaged in intricate and shared movements across many subtle dimensions, yet all strangely oblivious that they are doing so. Even total strangers will display this synchronization. Such synchronization appears to occur continuously if the interactants remain attentive and involved. Thus it is only a limited portion of communication which can be conceived of in terms of the model of messages sent and received. A listener usually does not move as much as a speaker. There will be moments when he remains quite still. But if the listener moves, even when reaching for a pack of cigarettes, etc., his movements will tend to be synchronous with the articulatory structure of the speaker's speech. The specific body parts and their directions of movement often differ from those of the speaker. In essence, a new concept of response is being presented where it is postulated that an almost immediate entrainment of the bodily organization of a listener occurs with the structure of the incoming auditory signal, particularly speech. This interactional synchrony, which seems to be a constant and important aspect of all human communication (over 100 films have been studied, including many cross-cultural films), was the primary factor leading to the hypothesis of delayed response to be described later. In Figure 4, to illustrate, the listener's body moves in configurations which are isomorphic with those of the speaker. This is seen in the vertical alignment of the arrow points, which indicates shared process unit boundaries. This is from the same dyadic interaction as Figure 2.

In Figure 4 are shown 5 articulatory segments of the word "keeping": /kkk/, /iii/, /pp/, /p'ƶ̇ƶ̇/, and /ŋŋŋ/. All of these seem to be relatively unitary entities except /p'ƶ̇ƶ̇/. Thus /kkk/ lasts for 3/48 second, /iii/ also for 3/48 second,

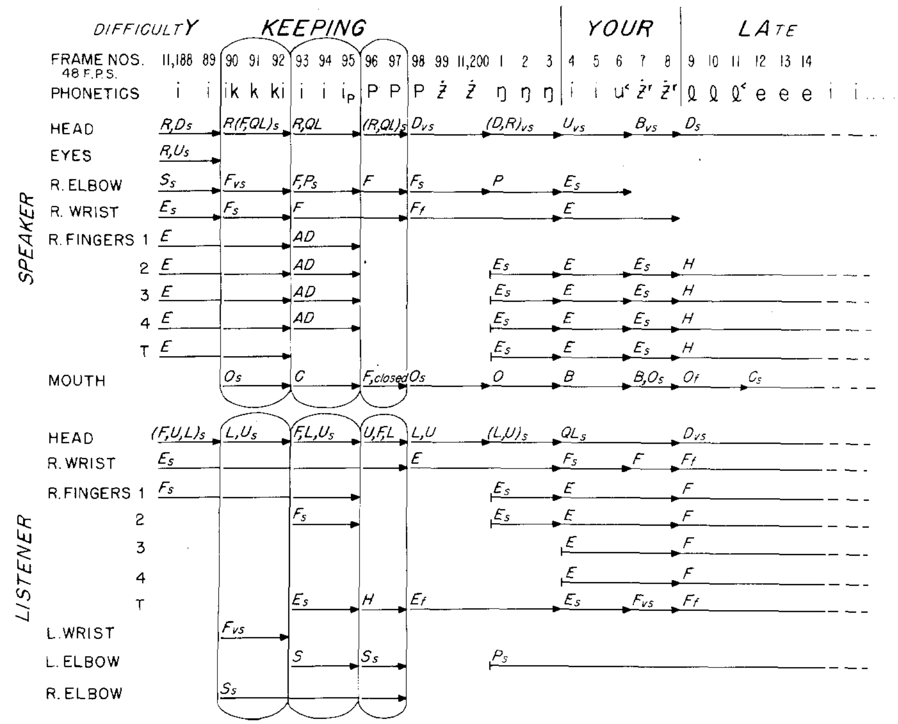

Fig. 4. Interactional synchrony in the isomorphic movement pattern of listener's body in relation to speaker's speech.

/pp/ for 2/48 second, etc. The /p'/ of /p'ɨ̇ɨ̇/ is the release /p'/entering the high mid vowel /ɨ̇/ and is a unitary part of that articulatory gesture. This is also seen in the lip movements. There are 5 kinesic "configurations of movement" of the speaker which precisely cooccur with these articulatory segments. The speaker's body thus moves in process units which are isomorphic with his own speech, as was seen in Figure 2. Some of these are also circled in Figure 4.

The listener also moves in a pattern which is synchronous with that of the speaker, although his configurations of movement are composed of different body parts moving. Across the 3/48 second of the emission of /kkk/, his head moves left and up slightly (L, Us), his left wrist flexes very slightly (Fvs), and his right elbow supinates slightly (Ss). Such synchronization is a continuous and ongoing aspect of conversation at the microlevel. The feature to be emphasized is the synchronization of the process units of listener behavior with those of speaker behavior. Interactional synchrony, to reiterate, is characterized by the boundaries of the process units of a listener's behavior occurring isomorphically with the articulatory boundaries of the segments of the speaker's speech. The process units thus provide a precise, microcriterion of response below the level of the stimulus–response model. Reliability studies, while still in an early phase, indicate that a high level of agreement is obtainable in kinesic segmentation between independent judges. Four varieties of reliability analysis (of binomial form) were carried out, with 86, 90, 97, and 93% agreement between independent judges. Estimated limits for similar percentages of agreements to be reached in random samples from a binomial population would range between 80 and 99% at $p = .025$ (Mainland, 1963).

The existence of synchronization between speaker and listener is thus defined by this sequential cooccurrence or isomorphism of the boundaries of the process units of each. For example, if a speaker has a sequence of linguistic-kinesic process units of order and frame dimensions 2, 3, 3, 2, 3, 3, 1, 1, 4, etc., and the listener has the same, then synchronization is postulated to be occurring. These, again, are forms of the organization of movement of the whole organism as a behaving unity. (Arms, hands, or legs do not behave; it is the total organized person who behaves.) All movement is thus postulated to occur in terms of such organized "quanta." Hence a listener, when he moves, will also move in forms of such process units or quanta. The startling finding, however, is that a precise synchronization occurs between speaker and listener and that this synchronization appears to be heavily auditory in nature. It can also be mediated by vision and touch, but this does not appear to be the dominant modality in normal behavior. A silence may occur during a conversation, and at the precise 1/24 second that the speaker resumes speech the listener will begin a new process unit. This cooccurrence of the onset of speech and the onset of a new configuration of movement in the listener characterizes the precise entrainment of interactional synchrony. The phenomena of self-synchrony and interactional synchrony seem to be basic and fundamental characteristics of human behavior and are evident from the day of birth (if not earlier). The normal neonate moves synchronously and rhythmically with the articulatory pattern of the mother's speech (Condon & Sander, 1974). Such synchronization provides constant feedback to the mother that the child is responding, even though she is, perhaps, not "consciously" aware of this. The infant naturally and actively participates in the enfolding rhythms of sound of the language of its culture. This suggests that the auditory process plays a very important and early role in socialization and enculturation. An infant having a defect in auditory processing could well encounter difficulties in learning speech and in developing human relationships, both of which seem to depend importantly on adequate sound processing. The process of interactional synchrony provides an important index of auditory responsivity to sound patterns, and microlinguistic-microkinesic techniques provide a method to study the developmental organization of such responsiveness.

RESULTS: DYSFUNCTIONAL AND AUTISTIC-LIKE BEHAVIOR

Emphasis in the preceding sections was placed on the very great synchrony and organizational order in normal behavior, including a description of analytical method. This synchrony, occurring across multiple, rhythmic dimensions, is one of the most fundamental observations to emerge in microkinesics. No single act is probably ever repeated exactly the same, yet all normal behavior displays this organized integrity during acts. Such constant and impressive precision through varieties of changes testifies that it is a unified organism who behaves and that this unity infuses all behavior.

A major strategy of the research has been intensive analysis of normal behavior across many dimensions in order to use this as a contrastive basis for the analysis of pathological behavior. Ultimately, a concept of pathological organization gains intelligibility in terms of some form of comparison (contrast) with behavior considered to exemplify normal organization. The microkinesic approach, using the sound-film and frame-by-frame analytical techniques discussed above, also provides a precise method for the study of pathology. An intensive microanalysis of sound films of subjects having various syndromes (parkinsonism, petit mal, autism, aphasia, stuttering, schizophrenia, Huntington's chorea) led to the postulation of a phenomenon tentatively called "dyssynchrony" (Condon & Ogston, 1966). Dyssynchrony, and the ways it differs from synchronous behavior, is empirically describable from microlevels to macrolevels. Such analyses indicate the potential importance of these emerging analytical methods which permit a controlled and effective inquiry into such difficult-to-understand behaviors. This is particularly relevant when the "variables" themselves are unknown and cannot be anticipated, which is the situation concerning many areas in the study of pathology.

In terms of the hypothesis of interactional synchrony, relatively immediate entrainment enters into the determination of when a subject can be said to have "responded" (in one sense of "respond") to a sound which occurs in close proximity. Synchronous entrainment between two "systems" is seen in both self-synchrony and interactional synchrony. Thus a serial cooccurrence of order between two systems or behaviors indicates some form of relationship between them. Several years of frame-by-frame analysis of sound films of dysfunctional children led to the hypothesis that some of these children respond to the same sound more than once. Their behavior is pathologically organized in complex ways and the response to sound more than once is only one aspect, yet one that helps account for many of their strange behaviors and may contribute to an understanding of their difficulty. Later occurrence of patterns of body movement configurations having the same serial ordering as sounds which occurred earlier (and this systematically) is the basis for postulation of a response to a sound twice, or even more often. The emphasis is on "systematic." Later body motion occurs as if the child were moving synchronously with a sound pattern but that sound pattern occurred earlier. Many of the behavioral mannerisms of these children can be systematically related to "sound events" occurring to them after some degree of delay, often as much as ½ to a full second. (Since earlier sounds are so precisely and systematically related to the later body movements, there is a tendency to describe the phenomenon as a multiple response to sound. This relationship, although precise, may of course be related to dysfunctional, neural sound processes which give rise to motor innervations that look like an overt response to sound.) The situation is quite complicated, however. The child also responds to the immediate actual sound as well, so that in some instances, particularly with long sequences of sound or speech, he will have the delayed sound seemingly overlapping into the ongoing immediate sound. At these moments, his behavior tends to become very rapid and jerky. It is not just a delayed response but a multiple response. This paper will seek to present observations supporting the hypothesis that some dysfunctional children respond to sound more than once (delayed) and that such "response" can be demonstrated by an extensive isomorphism between their later body motion and earlier-occurring sound patterns.

Prominent characteristics of the kinesics of these children are sudden and rapid movements which appear to have no relation to environing circumstances. An example may illustrate the situation. A 2½-year-old child throws a block on the table, which makes 4 distinct sounds, lasting 4, 4, 3, and 2 frames, respectively, before it comes to rest. He picks up another block and his hands suddenly move in a jerky and distorted fashion which seems bizarre. An intensive linguistic-kinesic microanalysis of this whole sequence of events reveals the following pattern. The child's body moves in 4 configurations of movement or process units which are synchronous with the actual sounds made by the block. This is the immediate sound. These movements tend to be relatively subdued in the sense of not being markedly rapid. At a certain time period later, in the present instance 16 frames, the jerky hand movements occur. (There are 24 frames per second, f.p.s., in standard movie film.) Microanalysis reveals, however, that the hands move in process units which are isomorphic with the sound that occurred 16 frames earlier, having a 4, 4, 3, and 2 sequence. (The sound on a copy of this child's film was deliberately delayed 16 frames by the film laboratory so that the actual sound would occur with the later body movements. It is quite startling to see the child move in precise synchrony with these now delayed sounds which actually occurred 16 frames earlier.) Such isomorphism remains systematic and exact down to the level of 1/24 second for most sounds throughout the film. Thus when a loud sound occurs one can count out for 15 frames from the onset of the sound and predict that precisely on the 16th frame the child's body will usually jerk as if at the onset of a sound. No actual sound is occurring at this later time, yet the child's body moves as if sound were occurring. Some of these children look around as if to see where the sound is coming from and seem puzzled. In the illustration above it is almost as if the block in the child's hands were alive and making the noise. These children entrain later with the ongoing pattern of the earlier sound, including subtle loud and soft modulations, even speeding up later at points where the earlier sound was louder.

The length of time of the hearing delay in these children, which seems inordinately long, requires explanation. If the microkinesic hypothesis that behavior occurs as an integrated and self-synchronously organized rhythm hierarchy, composed of cycles across the multiple levels of phone, syllable, word, ½-second interval, and 1-second interval, is correct, it may provide a basis for further exploration. Delays or other phasing problems within such a processing hierarchy, having cycles of these dimensions, might give rise to delayed auditory processing of similar dimensions. One of the most marked features of the response to delayed sound is the seeming lack of control of these children over their own bodies. They seem as if jerked this way and that by the sound. Most of them tend to move more at the delayed time than when the actual sound occurs. It must be stressed that most of these children do not appear to hear sound more than once although their bodies move as if this were the case.

The hypothesized phenomenon of response to "delayed sound" has thus far been observed in 25 subjects, ranging in age from 2 months to 25 years. The children had a variety of diagnoses, indicated in Table I. All have been seen by various children's agencies. While case history material is obviously important, it is not presented extensively at this time because of space limitations. Data will be presented on 2 of the children to illustrate the phenomenon.

Case 1

The first case is that of a 2½-year-old white male. This is the same child described in the earlier illustration. He was born by cesarean section, weighing 7 lb 6 oz. The pregnancy and delivery were considered normal. The child seemed to be developing normally until approximately 1 year of age, when his father began to feel that there was something wrong with his motor behavior. The parents, however, did not seek medical attention until he was 2½, when they became further concerned. He did not walk until he was 18 months old and had not developed any words by the age of 2½. An audiological examination ruled out the possibility of a significant hearing loss. The opinion of personnel of the several agencies that saw this child was that he was significantly delayed in overall development and had some degree of retardation. It was at this time (1971), when he was 2½, that a sound film was made for linguistic-kinesic microanalysis. Intensive frame-by-frame analysis revealed a marked self-dyssynchrony. It was also hypothesized that he was hearing sound twice (Condon, 1971). A careful neurological examination, however, found the child to be

Table I. Delay Times of the Second Response to Sound in Dysfunctional Children

Child	Sex	Age	Diagnosis	Delay time in frames
1	Male	2½	Retarded	16[a]
2	Female	3½	Autistic-like	18[a]
3	Male	6	Retarded	23[a]
4	Female	6	Autistic-like	23[a]
5	Female	7	Cerebral palsy	15[a]
6	Male	8	Autistic-like	18[a]
7	Male	9	Autistic-like	17[b]
8	Male	11	Autistic-like	15[b]
9	Male	12	Autistic-like	17[b]
10	Male	12	Autistic-like	16[b]
11	Male	5	Autistic-like	15[b]
12	Male	4	Autistic-like	14[b]
13	Female	8	Retarded	15[b]
14	Male	25	Autistic-like	8[b]
15	Female	2 months (8 days also)	Anoxic at birth	14[b]
16	Male	5	Autistic-like	10[b]
17	Female	11	Autistic-like	12[b]
			Reading problems:	
18	Female	10	Partially deaf and slow learner	4 and 8[b]
19	Male	17	Reading problem and slow learner	10[b]
20	Female	9	same	4[b]
21	Female	9	same	4 and 8[b]
22	Male	10	same	2[b]
23	Male	12	same	4[b]
24	Male	9	same	7[b]
25	Male	8	same	5[b]

[a]Film speed 24 frames per second.
[b]Film speed 30 frames per second.

within normal limits. Continuing microanalysis revealed an isomorphism between his body motion and sounds which had occurred earlier (including human speech). This was sustained systematically throughout the entire film. At one point in the film, he pounds on the table and stops, then looks at his hands at rest on the table. His head jerks precisely on the 16th frame later (or 2/3 second) as if in response to the delayed sound of his hand hitting the table. He turns and looks inquiringly at his father. Who or what made the sound? This child had a moderate response to immediate sounds and seemed in good synchrony with his own vocalizations. One of the startling aspects of the behavior of these children is the later response to their own voice as if it too were delayed to them. There is evidence suggesting that some of these children, including this 2½-year-old, entrain visually; they will move synchronously with the structure of movement. For example, one 3½-year-old autistic-like girl moved in precise synchrony with a series of movements of her mother's arms when the

Table II. Results of Microanalysis to Predict Delayed Response to Sound

Child	Number of sounds	Number of hits	Percent	Estimation error risk[a]
1. Child 1 in Table I	150	125	84	77–88
2. Autistic twin	116	93	80	72–87
3. Normal twin	116	18	15.5	9.1–23

[a]The figures in this column represent, for the .025% level of confidence, the maximum risks of overestimating the lower limit and of underestimating the upper limit for random samples, having the percentage of hits for the number of sounds. The values were obtained from Mainland's Table II, Limits of Binomial Population Percentages of *X*'s Estimated from Random Samples (Mainland, 1963).

mother removed a box of toys from a shelf. If sight organization is intact, these children may derive a sense of pleasure in moving visually with moving objects. Through sight they may gain some sense of relative coherence and order. Table I gives the delay times for all 25 children studied.

The 2½-year-old boy (Child 1 in Table I) was filmed while playing with wooden blocks at a table. This later proved useful since the blocks made clear sounds as they struck the table, often providing additional visual evidence for sound placement. The frame number of onset was located for 150 consecutive sounds from this film (each frame of the film had been numbered for identification). After the onset points of these sounds had been located, the body motion at the 16th frame following such onset points was microanalyzed to determine if a body motion boundary point also occurred. It was found that 125 body motion boundary points (or 84%) occurred precisely at the 16th frame. Further, there often was a rapid offset movement precisely at the frame where a termination of such a postulated delayed sound should have occurred. These sounds varied in length. For example, if an actual sound onset occurred at frame No. 10 and lasted for 4 frames, there would tend to be a movement boundary at frame No. 26 (16 frames later) and another movement boundary at frame No. 30, corresponding to a postulated delayed noise lasting 4 frames. These results are presented in Table II.

Figure 5 presents 2 examples of this child's synchronization with earlier speech. In the first example, the father, who is sitting to the child's right, says, "D'ya wanna go bye?" This sentence actually begins 16 frames earlier at frame No. 8104. In the 2 examples in the figure it is shown delayed 16 frames in relation to the body motion occurring at that later time. The boy has minimal response to the sound when it actually occurs. However, 16 frames later his body moves in process units which occur synchronously with the articulatory structure of the earlier sentence. Precisely at the end of the sentence his head moves up and right very fast toward his father. In normal behavior, a child's eyes and body motion are responsive to the parent's voice. They follow sound and are

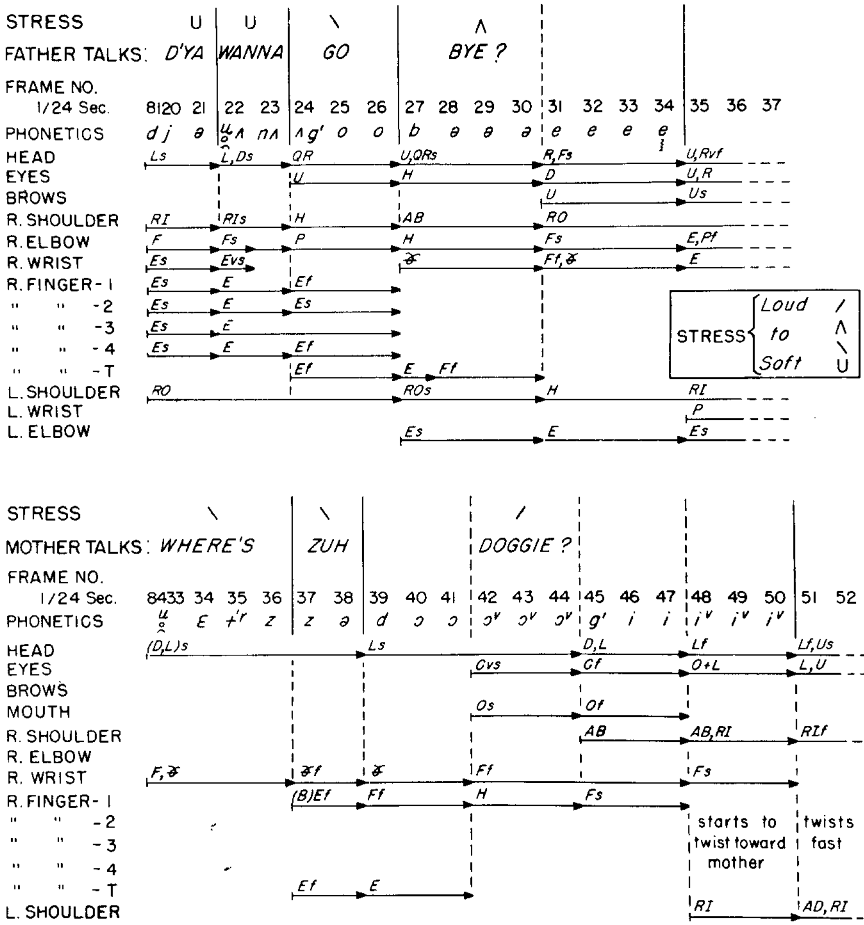

Fig. 5. Two examples of delayed response to sound in a 2½-year-old boy. This child was initially diagnosed as retarded, later amended to aphasic. The sound indicated in this figure actually occurred 16 frames earlier.

in the right place at the right time in synchronous rhythm with the parent's voice. The dysfunctional child looks almost "normal" at his delay time, but this is out of phase with the basic communicational rhythm of the culture to which he is supposed to adapt. Perhaps those around him withdraw from him because he seems unresponsive and he, in time, despairingly withdraws from them. In the second example, the subject's mother, who sits to his left, says, "Where's zuh doggie?" Again the child moves synchronously 16 frames later with the articulatory structure of the earlier sentence. At the end of the sentence, there is a rapid movement left toward his mother. There are 4 degrees of stress usually indicated in the notation of American English. In normal behavior, a listener will often increase speed of movement across the louder (stressed) portion of a speaker's speech. In the examples given, the boy increases speed of movement across "bye" and "doggie" (which are the loudest segments) as if they were occurring at that moment. This further supports a hypothesis of delayed response.

Case 2

In order to begin to test the hypothesis of a synchronization of the body motion of these children with delayed sound, the following analysis was conducted. This constitutes the second case to be presented. In one of the films a pair of 8-year-old twins are sitting on each side of their mother at a table. The boy was diagnosed as autistic-like and the girl is normal and bright. They have wooden blocks and wooden puzzles to play with, so that there are many instances of inanimate sounds. It had been ascertained that the delay time for this boy was 18 frames (Child 6 in Table I). Thus the prediction is that precisely at the 18th frame after the onset of a sound the boy will change configuration of movement; i.e., a new process unit boundary will occur at that point as if a sound were occurring in terms of the hypothesis of interactional synchrony. A further prediction would be that the normal twin would have many less process unit boundaries occurring at the 18th frame. Both children were subjected to the same sound stimuli.

The film was analyzed in the following fashion. All distinctly occurring sounds that were preceded by some degree of silence were selected for the initial study rather than more complicated groups of sounds. The onsets of 116 consecutive sounds were located in relation to a frame number. As with the earlier study, precision of correlating sound onset with a frame number was enhanced because the sound often occurred at the precise moment a block was observed to strike the table. After these sound locations were identified, the body motion of both twins was microanalyzed 18 frames after each sound to determine if a process unit boundary also occurred at that point. There were 93 boundary occurrences at the 18th frame for the autistic-like twin and only 18 for the normal twin. These results are also presented in Table II. Normal children do not display later body motor patterns which seem to vary systematically with earlier-occurring sounds.

There appears to be a continuum from autistic-like behavior at the severe end to learning disabilities at the milder end. This continuum seems to be related to degree of delay of the extra response(s) to sound; tentatively, the greater the delay time the more severe the disability. It was quite surprising to find a delay also occurring in children with seemingly mild learning disabilities. It was not possible to detect motor abnormality when talking with them. They all talked well and seemed of average intelligence, but had difficulty reading and doing arithmetic. Table I indicates the tendency for children with more severe dysfunctions to exhibit longer delayed-response times.

Other Examples

One of the fascinating (and disturbing) features of the delayed response is the apparent dominance it exerts over behavior. As previously mentioned, these children seem jerked this way and that by the sounds. This is a metaphorical, although not exaggerated, description of what it looks like on the film. They even move in delayed response to their own voice, and this applies to the children with the reading difficulty as well as to the autistic-like children. From another perspective, the delayed response could be conceptualized as an inappropriate, out-of-time innervation of the behavioral organization. Much of the awkwardness in the movement of these children is a result of this repeating innervation occurring in the middle of ongoing movements. A child reaches for an object, his body and arm "jerk" in delayed response to an earlier sound, and he knocks over the object. Again, a child walks across the room, the same thing occurs, and he lurches to one side. These children seem to be in the control of the sounds. We do normally what the dysfunctional child does abnormally. The organization of a normal listener's body movements appear to "dance" precisely with the articulatory structure of the speaker's speech. In similar fashion, the body motion organization of these dysfunctional children also moves with speech and sound, but then it moves again after a delay, and, for some, possibly even yet again. Normal children tend to ignore most immediate, inanimate sounds, continuing uninterruptedly with their play. Two 3½-year-old normal children were filmed (as controls) playing with toys. Many loud sounds were made behind a partition but these children ignored them. Our hearing, then, seems normal or correct when it is properly entraining with the structure of sound, at least with those to which we are attending. We hear what is there, as natural structure, to be heard. We do not hear what is not there. The sources of sounds are also visually verified, as, for example, when a noise occurs exactly at the moment we see one object strike another. They are so verified thousands of times each day. Pathological, multiple entrainment of the organism to the same sound provides strong indirect evidence in support of the basic hypothesis of interactional synchrony.

This delay phenomenon has been observed as early as 8 days in 2 infants that were anoxic at birth.[4] One infant, anoxic for 7 minutes, has been filmed every month for 10 months and her delayed response time has remained precisely 14 frames. With 30 f.p.s. film, this is just very slightly under ½ second. The delay seemed more clearly marked, in the sense of being detectable, at 9 and 10 months than it was, for example, at 2 or 3 months. While the delay time has appeared to remain stable and precise for each child, it may change over time and so this infant will be filmed as long as possible. This procedure will be followed with other children as well. These observations indicate that the lin-

[4] The author wishes to particularly thank Dr. Jeffery Gould and the staff of the Neonatology Unit of the Boston City Hospital for their great help in obtaining films of infants.

guistic-kinesic microanalysis of sound films can provide a very early screening procedure for the neonate. It provides an assessment of hearing, for if the neonate synchronizes with the structure of sound, even very slight sounds, then one would surmise that these sounds are being heard. Very subtle asynchronies of movement, particularly of the face, can be detected through frame-by-frame analysis. In the infant described above, for example, very clear facial asymmetries could be observed at 8 days. At one point in the film the right eyelid is going down while the left eyelid is going up. But most importantly it is now possible to check for multiple response in at-risk infants, to determine the amount of delay, if it exists, to the precise fraction of a second. Continued research should provide increased diagnostic and prognostic information. The above infant looks very "normal" at the 14-frame delay interval. In contrast, none of the 16 normal neonates studied revealed such marked asynchronies or delayed response. A normal listener during interactional synchrony is providing constant feedback to the speaker. The listener's movements, which are synchronously organized with the articulatory structure of the speaker's speech, are probably in the awareness of the speaker at some level. These are very exact timings during such interactions. The 2½-year-old boy discussed earlier and this 10-month-old girl appear to respond late. They look up after they are called, which is in turn after an almost ½-second delay. They are out of phase with the timing of normal interaction. It must be emphasized that the criterion for delayed response is not an occasional later movement which seems to occur isomorphically with earlier sound but an almost constant and systematic cooccurrence. Thus it happens time after time that a child will be relatively still and exactly at the frame a sound (or neural event) is postulated to be recurring his body jerks as if he were startled.

DISCUSSION

The picture of man as it emerges from the linguistic-kinesic microanalysis of sound films of normal behavior reveals a creature incredibly organized within himself, in relation to his fellow creatures, and with the universe of which he is a part. It is a vital belonging and a coherent participation. When "pathological" change occurs, disrupting man's usual or "normal" relation with his world, concomitant processing difficulties of various degrees may also occur. This paper has presented observations suggesting that some, perhaps many, dysfunctional children may be responding to the same sound more than once. Most of them, to stress again, probably do not actually hear the sound more than once, although their bodies systematically move later with the pattern of earlier-occurring sound. This applies to a wide range of dysfunctional children, from autistic-like to those with reading difficulties. These observations, if substantiated by further research, indicate the important role that sound-film microanalysis can play in the study of dysfunctional behavior. It offers a precise, microscopic technique for interpretation of the organization of these behaviors in comparison with each other and with normal behavior, especially developmentally. Recent work suggests that a variety of classes of types of dysfunction along a continuum may be discovered by a careful microanalysis of the behavior. Future work will explore and widen our understanding of this new universe of multiple response to sound. For example, there appear to be cases where a response occurs many times as if sound were reverberating. It will be important to study the varying organization of the response structures, i.e., which body parts move and in what fashion. There is no clear-cut pattern of left side with delayed sound and right side with immediate sound or conversely. Both sides can move with either delayed or immediate sound. All of the children have displayed dyssynchronous behavior in contrast to normal behavior. This would suggest some degree of neurological involvement in the problem. There is no indication at the present time of what is causing this delay or where it might be located in the system.

While greater information is essential, the central issue of how one can help these children remains. If the above findings are correct, the children would be responding twice as much (if not more often) as normal children and physically moving a great deal more as a consequence. They might tend to be much more irritable and tired than normal children. It might prove useful to shield them from excessive noise. Speaking to them quietly and in short sequences to prevent sound overlap might also be helpful. The whole question of how to teach the autistic-like children speech and how this can be best achieved in terms of possibly distorted auditory processing needs to be explored. Many "retarded" children, if a delayed response factor is taken into consideration, may be similar to the 2½-year-old boy of Case 1. He seemed very much like a normal child in response to sound at his 2/3-second delay time. Many of these children may be desperately trying to comprehend and communicate in a distorted world.[5]

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[5] Future research, designed to verify the hypothesis of multiple response, is being supported by the Charles Weed memorial award.

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