Using Video
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Chapter 5

Computer-Aided Video

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Gesell (1935) presented a 'cinemanalytic' approach to the analysis of behaviour, formulating five main features. These have remained essential to all methods in film and video research:

1. The film being propelled at a known speed minutely records time values and sequences.
2. Simultaneously and also minutely the film records space relationships and configurations.
3. The film records these spatial and temporal data in a series of discrete, instantaneous registrations.
4. These registrations can be serially reinstated at normal, retarded and accelerated rates.
5. Any single registration can be individually studied, in terms of time and space, as a delineation of a single phase of a behaviour pattern or a behaviour event.

These five propositions are extremely simple but their methodological implications for the objective study of behaviour are far-reaching. In addition to his work on cinematic studies on early infant behaviour, Gesell also proposed the use of film in clinical analysis and clinical training.

The history of film technology in scientific research has been reviewed exhaustively by Michaelis (1955) and in the human sciences by Reuch (1975), himself an early contributor to the development of the anthropological film. What follows in this chapter should demonstrate how present-day technology provides the video user with substantial improvements in many, if not all, aspects of behavioural analysis based on audiovisual recording. Thus qualitative improvements in accuracy and detail of observation can be achieved with the aid of sophisticated camera and optical systems, audio equipment and other recording features. Furthermore, the convenience and low cost of much necessary equipment free the user from many technical problems and permit concentration on the actual task at hand—observation and analysis.

In psychiatry, film recording was recognized and used by various workers as a medium for the storage and objective comprehensive presentation of examples of psychopathology, apparently by Kraeplin before 1920, and later by Page in 1938 and Lehmann in 1952 (see Michaelis, 1955). Despite the restrictive processing time involved with film, use of this medium in psychotherapy for self-confrontation was used 30 years ago by Carrere (1954).

Although the tube-based video screen for television had been invented during the thirties, its first applications in behavioural research and psychotherapy were reported after the development of the videotape recorder by Ampex in 1956 (Ginsburg, Anderson and Dolby, 1957). The advantage of the video medium led gradually to its establishment in many areas of psychiatric research and practice (Berger, 1970). To avoid confusion and repetition, the term video will be used here, although in many aspects the discussion also applies to film recording. For a comparison of video and film, see Utz (1980).

Parallel to the development of video technology, substantial improvements in behavioural data collection methods and technology have been made. An excellent review of this area has been presented by Hutt and Hutt (1970). Essentially, the data collection involves the recording of specified behavioural events and their times of onset and offset (Fitzpatrick, 1977).

Since the introduction of the interaction chronograph by Chapple (1949), many elaborations and variations have been reported (see Hutt and Hutt, 1970). Naturally, reported devices have increasingly included the computer analysis of behavioural data (e.g. Hoehne and Maurus, 1973; Tobach, Schreirla and Aronsen, 1962; White, 1970). Recently a series of portable event recorders have also been described (Fitzpatrick, 1977). The SSR (signals, senders and receivers) system described by Stephenson, Smith and Roberts (1975) (coincidental acronym?) is representative in that it allows the researcher freedom to define and score behavioural sequences and to store these data in a manner that permits troublefree transfer to the computer for permanent storage and analysis.

In the past few decades substantial advances have been made in observational methods, audiovisual technology and computerized event recording. More recently, the integration of these three aspects of behavioural analysis has become feasible.

Direct and indirect observation

The techniques for audiovisual recording on the one hand and data collection on the other, have often been applied independently. However, the availability of suitable equipment permits the researcher to design and implement systems which draw from both areas.

The issue as to whether direct or indirect observation be selected has been discussed ever since the widespread availability of film and sound recording. Here, direct observation is understood as observation in a natural or laboratory setting performed with the aid of notes, checklists or event recorders, and without the use of picture or sound recording. Indirect observation is understood as observation of such picture and/or sound recordings after the event or in some cases via video monitoring. These two alternative behaviour–observation–analysis paths are illustrated in Figure 1. In this figure, the lower path corresponds to the direct observation design. Thus, each behavioural phenomenon is observed once by the observer(s), the scored data being stored intermediately for later transfer to a processing computer. The upper path corresponds to the indirect observation design. Here, the behavioural analysis is recorded audiovisually by one or more cameras and one or more microphones. The resulting videotape can then be observed repeatedly and in as much detail as the technical quality (camera angle, sound clarity, separation, etc.) permits.

For most applications it can be seen that the indirect observation design permits much more flexibility and accuracy in the observational methods—provided the behaviour specimen of interest can be adequately 'captured' on videotape. Once recorded, it is possible to 'reproduce' the behaviour in the laboratory where the convenience of computer-aided observation and data collection is available. The various audiovisual recording media enable repeated observation at various speeds, comparison of observational methods and performance of reliability studies. To quote Barker (1978, p. 12) from his studies in ecological psychology: 'The advantages of the filmed record lie in the preservation of details that are lost in verbal accounts and the opportunity to go back and look again.' The proponents of direct observation, however, argue with some justification that the analysis of social behaviour in contrived situations is questionable (Conger and McLeod, 1977). Furthermore, the observation and recording of data from persons who are unaware, whether by direct observer or audiovisual means, brings up an ethical issue which as yet remains unresolved (see Fields, 1978, and Schaeffer, 1975).

It appears to us that for any analysis which is aimed at exploring the structural aspects of social interaction, an audiovisual recording is necessary. This was formulated by Gesell (1935) and has recently been emphasized by Kendon (1979), outlining the principles of context analysis and the role of filmed 'specimens of behaviour' for the researcher interested in the study of behavioural relationships.

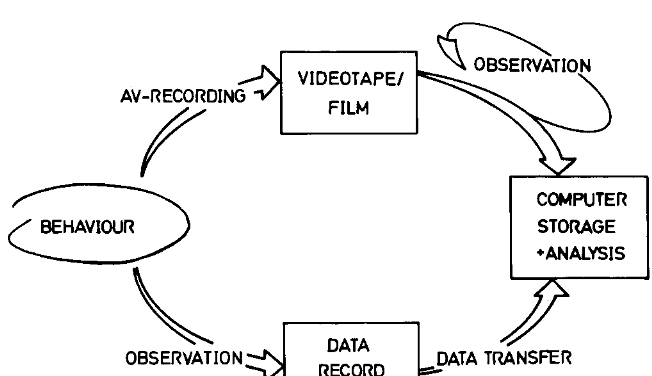

Figure 5.1

Video handling systems

For the behavioural scientist, the videotape serves as an intermediate storage medium for the behavioural phenomena or specimens which have been recorded. The advantages of video storage and current techniques employed in its applications in psychology are dealt with in some detail in the next two chapters of this volume. However, one disadvantage of the videotape as a storage medium is that the recorded information is not directly visible, as in film where a visual image is recorded on the carrier medium so that points of interest can be determined by direct examination or simple optical projection. With video, an electronic signal is recorded on magnetic tape and reproduction of the visual image requires a substantial amount of electronic circuitry. This can lead to considerable frustration, particularly when searching and evaluating recorded material.

This introduces us to the question of indexing the recorded material. The spectrum of possible systems for indexing tape reaches from the simple mechanical counters built into most machines through to computer-compatible coding and internationally transmitted radio time signals. In principle, the time-coding of magnetic tape may be likened to numbering the pages of a text. Considering that it would be unacceptable to neglect numbering the pages of a written text, it may be argued that a reliable indexing method for video frames should be included as a standard facility on video recording machines. The requirement of an adequate time-code is further endorsed because the time dimension plays an essential role in the examination of behavioural sequences. For applications such as role-playing and self-confrontation, it is likely that the mechanical counters built into most video recorders are adequate. However, for most observational work, the imprecision of such counters quickly becomes noticeable. Basically, this is because these counters display tape position as a measure derived from the tape length, rather than referring to the recorded video signal.

When measurement is made with direct reference to the video signal, the sync component of this signal, which is the electronic equivalent of the sprocket holes on a roll of film, can be used as an electronic trigger, so that frame accurate counting is achieved; i.e. the individual video frames are counted, rather than the tape length. Various 'video coders' using this technique have been developed for tape indexing. These generate an on-screen time display in hours, minutes, seconds and frames on each video frame. In principle, this technique is identical to that described by Van Vlack (1966) for the indexing of film in psychotherapy research. With video, however, this system has the disadvantage that it can be read only at play speed and in slow motion (and with some recorders in jogmode), but not in fast wind or rewind. A further disadvantage is that the time specification cannot be read automatically by an electronic decoder or computer.

Recently, however, a number of systems using computer-compatible time-coding have been developed which, among other things, overcome this problem. Such systems possess all of the advantages of the previously described indexing methods—above all, frame accurate coding and read capability at all tape speeds. Of greatest importance is the fact that these digitally recorded time-code signals can be read by the computer. This enables the constant monitoring of tape position and programmed control of the videotape machines.

The widely recognized difficulties arising from the collection of large amounts of video material, and the need to protocol and evaluate this efficiently, have played a major role in the recognition of the need—primarily in the professional television studio—for automatic techniques of indexing and controlling videotapes. In psychological research, these developments were foreseen by Ekman and Friesen (1969) and included in the design of their video information and retrieval systems VID-R and SCAN. As in Gesell's earlier system, such features as different viewing speeds, search and retrieval, temporal reorganization and access to a visual library collection are included in the concept. Of crucial importance, then, is the vastly improved user convenience made possible by currently available audiovisual and computer technologies.

An ambitious system which includes the possibility of transferring video images onto computer graphics was proposed by Futrelle (1973). This system, GALATEA, allows the user to produce animated line drawings of those aspects of the recording which interest him or her. A more modest system operating on the same principle has been implemented by Wallbott (1980) for the automatic measurement of hand movements.

A system for the protocolling and retrieval of audiovisual data (PRAVDA)

A system incorporating the advantages of computer-controlled video recorders and data collection equipment has been developed at the Max Planck Institute (MPI) of Psychiatry in Munich. The organization of the system is illustrated in Figure 2, where three basic levels of operation are represented.

Thus, at level 1, the user would work directly with the video machines, all control operations being performed by hand. At level 2, a wide range of instrumental aid may be introduced. This level includes the sophistication offered by the numerous remote control units and edit controllers available at this date. At such a level of integration, in principle, manual operation of the

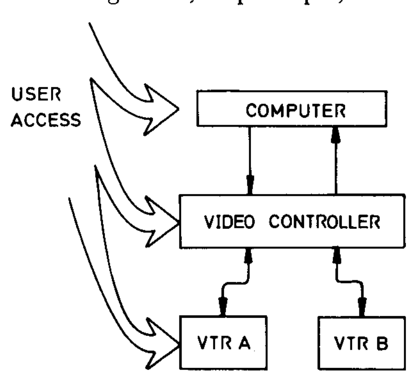

Figure 5.2

individual video recorders is no longer necessary. At the third, most complex level of organization, the remote control of the video recorders is performed by programmed routines; e.g. all search and edit functions may be performed automatically according to specified time entries. Further applications which capitalize on this level of sophistication include the collection of observational data and time-codes from video material, their storage and analysis. This corresponds to the integration of the event recorder, as described earlier, into a computer-supported video system.

In the remainder of this section we describe major aspects of the MPI facility, as applicable to other settings. In particular, we discuss video indexing, or time-coding—a prerequisite for accurate time specification and tape control, microprogrammed control routines and computer-aided operation on the MPI facility and observation and data collection techniques.

Video indexing

A central feature of the MPI facility is the synchronous recording of a time and control code in addition to the video and audio signals. The time-code is nothing more than a series of binary pulses which form a digital clock signal. One series or codeword is recorded per frame. The time-code signal is recorded on a separate track on the videotape and provides synchronous frame-accurate indexing of the video material. The time-code signal can be recorded either directly, in the case of a studio recording, or during transfer of material from a portable video recorder. Thus, it is possible to play back or 'reproduce' the behaviour in the laboratory where the convenience of computer-aided observation and acquisition is available.

The time-code used is the standard time and control code for videotape recording developed by the Society of Motion Picture and Television Engineers. It corresponds to the standard proposed by the International Electrical Commission (1974). Such a code is the key to efficient indexing and electronic control of videotape. Essentially, the time information is coded in binary coded decimal form, and can be recorded on the second audio channel of the videotape—if available (see Figure 3)—and/or inserted into the video signal during the so-called vertical blanking interval between frames. (Standard television systems do not use all lines for the transmission of picture content. In the vertical blanking interval several lines are free and can be used for inserting test signals, time-code and other identification information.)

The digital codeword for each video frame includes the following information:

> Hour, minute, second and frame count, an eight-position alphanumeric word for content coding and a sync word which indicates the end of frame and direction of tape motion

This enables reading of the time-code at all tape speeds from fast wind/rewind down to frame-by-frame step motion. The fundamental advantage with time-code is that any programmed routines (e.g. tape search, edit) are synchronized to the video signal and operate to frame accuracy. In order to perform such routines, those points in time (i.e. entrances and exits for each scene) at which the recorders have to be switched must be stored.

The definition of the stored points can be carried out in three ways:

1. The time information can be entered by hand via a keyboard. The entered data are then assigned to corresponding storage locations.
2. During observation at the video monitor an arbitrary number of points in time can be stored by push button. The time information thus selected is assigned to a data file in the process computer and may be complemented by content classification data.
3. The time information may be transferred from a data file which has been assembled earlier.

Microprogrammed control routines

Essentially, the handling of time-coded videotapes involves various combinations of three basic control routines:

1. Searching tape for a defined point in time
2. Presentation of a temporally defined scene
3. Frame-accurate editing of selected scenes from production tapes to the edited tape

These routines are controlled in the PRAVDA system by a hard-wired microprocessor (see Figure 4).

The search routine involves the controlling of one video recorder so that the videotape is positioned to any given point in time on the tape. The tape position is monitored by continuous reading of the recorded time-code, and the tape speed is program-controlled according to what might be termed a 'ballistic' curve, so that an optimum access time is achieved. The routine for the pres-

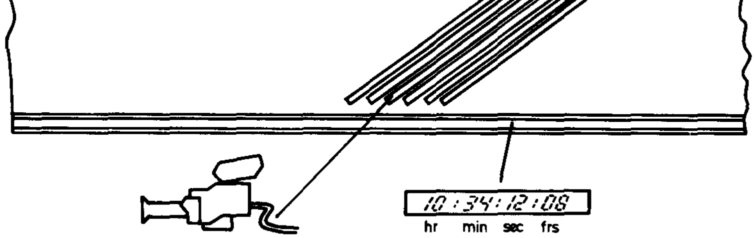

Figure 5.3

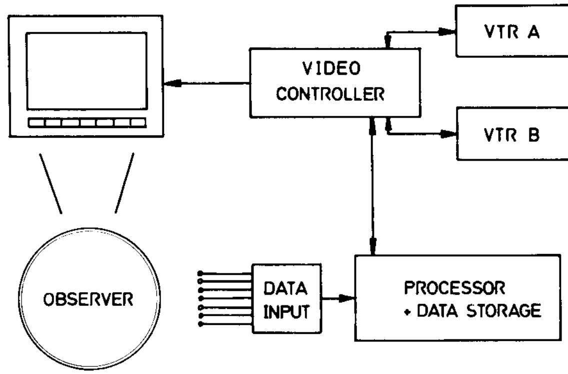

Figure 5.4

entation of a temporally defined scene involves, first of all, a search routine so that the tape is positioned shortly before the entrance to the scene. The recorder is then switched into play mode and after the cue-up time, during which the recorder stabilizes mechanically, the video and audio signals are switched to the monitor exactly at the selected entrance. The signals are then switched down at the exit time of the scene and the machine is halted. Since the beginning and ending points are stored, the scene can be presented repeatedly with negligible delay.

Editing of tapes involves essentially the same routines being carried out for two or more machines. Thus, the machines are positioned to their respective points in time for the edit. The edit can then be simulated or executed by switching the edit machine to record mode at the beginning of the scene. The configuration used in the PRAVDA system allows the transfer to and from the computer of time and content data, and enables high-level monitoring of the video functions. The program systems developed include procedures for the assembling and storage of protocols and edit lists as derived during an observation or analysis phase, associative search algorithms for the assembled data files and fully automatic editing procedures. All of these programmed routines derive their time reference from the time-codes recorded on the videotapes so that absolute synchronicity to the video content is maintained.

Observation and data collection

This mode of operation has been designed for the acquisition of binary states or events together with their time of occurrence and their duration. The essential features in this mode of operation are:

1. Multichannel input of observation data and their times of occurrence
2. Synchronicity of recorded data with videotape time-code

The binary channels can be driven by automatic speech detection circuity or by a human observer. Specifically, the system is equipped for two independent acoustic channels and up to eight observer channels which can be freely allocated (see Figure 4). The time reference is obtained from the synchronously recorded videotape time-code. Absolute synchronicity to the recorded behaviour is thus achieved with a resolution of 40 ms, corresponding to the individual addressing of each video frame.

The speech detector is designed to process two audio channels. It operates in the following fashion. In each channel, the envelope of the audio signal is derived and presented to a threshold detector. The presence or absence of a signal is determined by comparison of the signal envelope level with a selected threshold level. This threshold is set manually according to the dynamics of the incoming signal. The envelope signal is displayed on an analog meter and the output of the threshold detector by a LED diode. These enable the operator to establish the optimal setting for the threshold levels.

In this manner, the speech detector transforms speech into an on–off pattern. Since the detector was initially designed for the recognition of human speech during dyadic interaction, due consideration had to be given to the compensation of any cross-talk between channels. Lavalier microphones were selected for transducing the speech signals; this microphone type offers excellent directional characteristics and is therefore effective against acoustic cross-talk. In addition, electronic compensation was included so that, after envelope detection, the envelope level from either channel could be subtracted from that of the other channel, the attenuation factor of the subtracted envelope signal being manually adjustable. This factor is set for each channel to give optimal suppression of cross-talk. The resulting corrected signals are then presented to the threshold detectors, which in turn deliver the required binary signal.

Besides the two speech channels, the unit is equipped with an additional eight binary channels which are switched by observer keys. The input switching is processed together with the speech detector outputs, in buffer stages, for the interface to a PDP8F computer. The computer interface consists of a custom-wired module. The incoming binary signals are wired to the data lines through programmed buffer stages. The device and function selection facilities are programmed so that the data lines may be cleared, loaded and read into the central processor.

Observation may be performed in a number of modes; e.g. in real-time during recording, in real-time during playback, in slow (or fast) motion during playback. (Further possibilities include the synchronous, frame-accurate playback of two video recorders.) The video material presented for observation is accompanied by the synchronous time-code signal. The computer registers the behavioural states delivered by the observer keys and the speech detectors and allocates to these the corresponding videotape time-code.

More exactly, the detector and observer input lines are sampled repeatedly in a program loop; then, on the occurrence of a change in any input line, the time-code is read and stored together with the new input status. In this manner, the input channels are continuously monitored, the occurrence of events on any of the channels being stored for further processing. An excerpt from a typical four-channel data set is given in Figure 5; each behavioural state is listed with the point in time at which it commences. By using the recorded videotape time-code as reference, excerpts from the observed sequences may be exactly defined and analysed, and an identical time reference signal is allocated in the case of repeated observation. The resulting data set is initially stored in core; after termination of the observation phase, the data may be examined for plausibility and corrected as necessary before being written onto computer tape.

The temporal resolution for the chosen analysis can be set to any multiple of the basic video frame frequency. This is equivalent to setting a measurement resolution and may be considered as a high-frequency filtering of the data. By setting the resolution, for example, to five video frames (200 ms), any observed states which have a duration of less than five frames would be suppressed. The effect of varying the measurement resolution has been examined in connection with a general study of observer reliability (Wagner, Ellgring and Clarke, 1980). It was found that optimal validity and reliability is obtained from human observers of speech and gaze behaviour when a resolution of 280 ms is selected.

Application to single-case, longitudinal studies

The system described in the previous section has played an essential role in the recording, evaluation, and archiving of videotapes in connection with a long-term project involving single-case, longitudinal studies of depressive patients. The object of these studies has been to examine temporal changes in subjective mood and their relationship to observable changes in communicative behaviour (Ellgring and Clarke, 1978).

To date, 20 patients have been examined in this project. Each of these

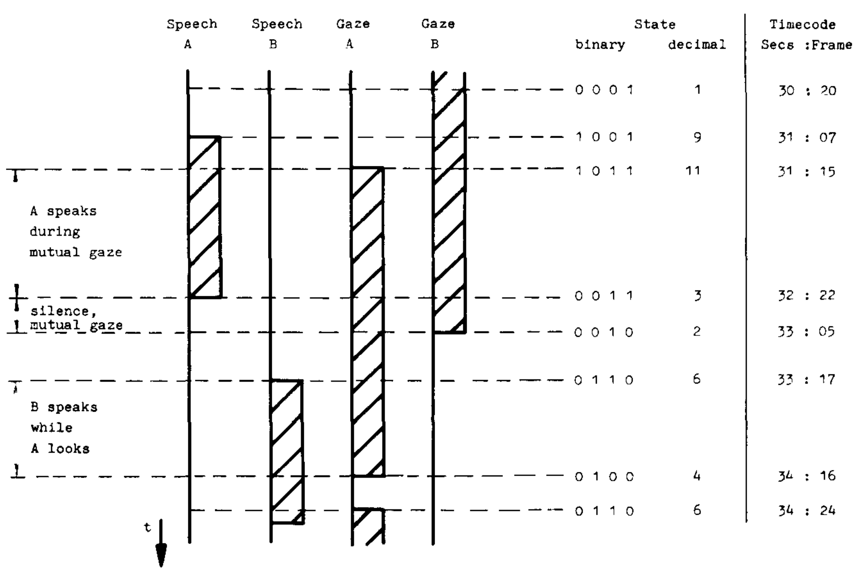

Figure 5.5

patients took part in clinical interviews which were performed twice weekly during hospitalization and during follow-up. This has yielded an average of approximately 18 interview recordings for each single case. The interviews have been scored and analysed for various verbal and non-verbal behaviours. This has included detailed observation of speech, gaze, gesture and facial expression, and rating of verbal content. In this section, the general strategy is demonstrated with the example of one single-case study.

The following brief results illustrate the different temporal courses of subjective and behavioural variables found in a 57-year-old female patient. As can be seen from Figure 6, the patient took part in 19 interviews over a period of 120 days during her clinical stay. Figure 6 shows the course of the patient's subjective mood rating. Initially this was good, showing a tendency to improve until the 25th day. During the next few days, a sudden lapse into a state of deep depression occurred. The subjective mood then appeared to improve again until the 80th day. A slight relapse occurred between the 100th and 120th day. The patient was treated from the 29th day with Amitriptylin.

For each of the interviews the speech and gaze of the patient and interviewer were observed as described in the previous section. This was carried out after each interview by four independent, neutral observers. In addition, a reduced number of interviews were selected for the analysis of gesture and facial expression. These were selected after the patient's remission when the course of the illness, as reflected in the subjectively rated mood and the measured speech and gaze, was known. Interviews were selected according to the extremes of subjective mood.

The analysis of gesture (Hiebinger, 1981) indicates that, among other things, a reduction of speech-accompanying hand movements and an increase in general manipulation are associated with depression. The results for the patient described here show that, as expected, worsening depression was accompanied by a continuous reduction in gestural behaviour. The analysis of facial expression is being carried out according to the facial action coding system (FACS) developed by Ekman and Friesen (1978). Initial results indicate that the samples from those interviews where the patient is more depressive contain fewer emotionally positive facial expressions (e.g. smiling) and more emotionally negative expressions.

The evaluation of gesture and facial expression, of course, involves more observer effort than the continuous coding of speech and gaze, some phases requiring frame-by-frame analysis. However, since all observational runs have as time reference the video time-code recorded on tape with the audiovisual material, this enables the synchronization of the data during subsequent analysis phases. This possibility has been explored to some extent by Wagner (1981) and Hiebinger (1981) for the contingent relationships among speech, gaze and gesture. This technique is based on the concept of signal-averaging, which is suitable for the separation of weak, but systematic, event-related effects from ongoing activity. In the case of social interaction, its application yields information on the intensity and latency of intra- and interindividual coordination.

An approach to the analysis of behavioural sequences based on a structural model has been developed (Clarke, Wagner and Ellgring, 1980). The model is based on the theory of grammars developed for the description of natural and

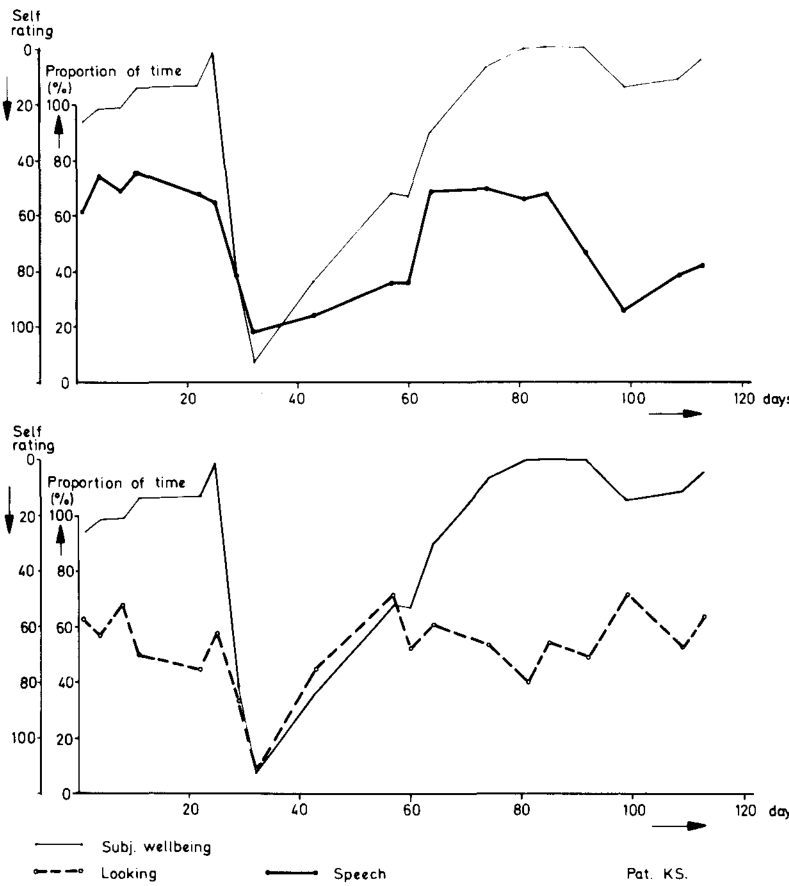

Figure 5.6

formal languages. Under the assumption that non-verbal communication consists largely of rule-governed behaviour it is proposed that a suitable grammar can be derived using this theory. Some attempt has been made to construct such a model and examine its usefulness for the examination of temporal sequences of speech and gaze patterns. The results permit interpretation of regularly occurring behavioural sequences which are governed by such factors as situation, interaction and subjective mood. All the complex analyses mentioned rely on efficient observation techniques and, above all, temporal synchronization of data collected during different observational runs by means of a computer-compatible time-code.

In addition to these formal analyses, editing strategies have been developed for condensed video presentations of the observable behavioural changes. These include the editing together of short sequences from each of the interviews with one patient. For example, the first 15 to 20 seconds of the patient's answer to a selected question are edited onto a second tape. Thus, the patient's response can be observed from interview to interview, and a general impression of the behavioural changes over the course of time can be obtained. Typically, these edited series involve excerpts from 20 to 30 interviews. In this way changes which have been found by statistical analysis of behavioural data can be collated and reviewed on video.

The single-case study outlined above indicates that there appears to be a systematic relationship between the temporal changes in the patient's subjective mood and the observed behaviour. Furthermore, the changes in gaze behaviour were found to occur in advance of the corresponding changes in subjective mood. Such temporal shifts may be explained as resulting from the existence of separate temporal systems governing the associated psychological levels (Ellgring, Wagner and Clarke, 1980).

Conclusion

The recent developments in microprocessor electronics and time-code equipment have vastly improved the efficiency of working with video material so that through the combination of data processing and video recording equipment a substantial rationalization of both data acquisition procedures and functional control of the recording machines may be achieved. Such a system, in which video editing and time-code control equipment is interfaced to a process computer, has been developed for the analysis of human communicative behaviour. The system provides exact indexing of the recorded material, automatic search and edit routines for the videotape machines and synchronicity of registered data. In summary, it can be maintained that given a sound theoretical basis, modern video and computer technologies can substantially increase the efficiency and accuracy of behavioural observation and analysis.

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