FROM OBSERVED VISIBLE HUMAN BEHAVIOR TO ANIMATED HUMANOID 3D COMPUTER MODELS - BIVARIATE NOTATIONS AS A PSYCHOLOGICAL METHOD FOR SYSTEMATIC OBSERVATION

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Abstract

Systematic observation of visible phenomena is especially in the exact sciences, e.g. Physics or Chemistry, without doubt one of the most important sources of knowledge and regarded as a prerequisite in those disciplines. For the comparatively young discipline of Psychology, which itself has been counted to the exact sciences since 1982 (ISCU, 1982) precisely detailed, high-resolution and unbiased observation of visible human behavior still remains a challenge. Mere recordings -whether photographic, on film or video- provide no directly measurable or calculable data about complex temporal or spatial human movement sequences, which is absolutely vital for scientific analysis. Finding a method by which visible human behavior can be notated in such a way so as to provide a most accurate true reflection of the observed behavior in the notation itself, has therefore, especially in Psychology, been a problem of the first order for decades.

The method of *bivariate notation* of temporal and spatial visible human movement behavior appears to have proven itself useful, particularly in the context of current work done in solving these problems. With the aid of a comparison between five trend-setting research efforts, this contribution thus aims to provide an overview of how this method has gained efficiency over time, from its early beginnings up to the most current stage of development.

Keywords: Systematic observation of visible human behavior, method of bivariate Notation

Introduction

After the Second World War, academic Psychology lapsed into the “worst provincialism” (Hofstätter, 1957), in the country of its founders, Germany, as shown in the context of the observation of visible human behavior in particular. Under the heading of “Expression-Psychology” (german: Ausdruckspsychologie), scientific observers “analysed” and “diagnosed” the movement behavior of persons in that they forced their own visual *impressions* onto the observed persons as so-called *expressions* of the latter`s inner attitudes, personality traits, etc. Publications emerging from this viewpoint, became the breeding ground for views which led to the foundation of national-socialist race doctrines. After the Second World War in Germany almost thirty years passed before in the year 1973 Expression Psychology was removed from the academic curriculum and cut from the examination regulations for graduates in Psychology (Michaelis, 1986). Yet, intensive discussion and analyses of the causes for the at least intellectual disaster- if nothing else- and the role of Expression Psychology and its methods of observation in this respect, did not ensue. As a result of the unresolved history, the further development of the systematic observation of visible behavior so evidently and enduringly stepped into the fringe, that even in the late 1960s, it was stated that “observation methods are ignored or underestimated by many social scientists” (Cranach et.al, 1969).

The US- American psychological community already distanced itself from the theses of Expression Psychology in the late 1930s, because it had not proven itself useful in psychological diagnostics, so that "the study of facial expressions and their interpretation died out by the 1940s" (Davis, 1979). Instead, attention in the USA was turned to the more easily controllable human *speech behavior*, concentrating primarily on the development of questionaires and tests, thus abandoning the interest in the systematic observation of visible human behavior. After no new, visionary theoretical impulse which could rekindle the subject of the systematic observation of visible behavior emerged in the USA for roughly one decade, a new research movement formed itself at the end of the 1940s under a heading which had previously found little attention: Communication. This development was initiated by the powerful American science manager, Warren Weaver. In 1949, he popularized a model for a *mathematical* communication theory of engineer Claude Shannon (Shannon, 1948) through a successful media campaign in which he suggested that this model could serve as a means to completely describe *human* communication (Weaver, 1949). Weaver's assertions found their way into the realm of academic Psychology through an influential Harvard University psychologist, George Miller, who as early as 1949 and in his lectures in the course of 1951, warmly recommended it to lecturers and students in his book "Language and Communication" (Miller, 1951). From that point on, visible human behavior in the context of the new theme of Communication, came to be described as "visible <u>non-verbal</u> behavior." Apart from the psychologist George Miller (Miller, 1951), the introduction of the description non-verbal can especially be attributed to the American psychiatrist Jurgen Ruesch, who published the noteworthy book "Communication" in co-authorship with the anthropologist Gregory Bateson in 1951 (Ruesch & Bateson, 1951).

The bivariate notation of visible human behavior
Ray Birdwhistell`s trailblazing work on methodology

Also the anthropologist Birdwhistell (1918-1994) published his work, *Introduction to Kinesics* (Birdwhistell, 1952), under the new, larger field of Human Communication. The thematic emphasis of his publication was the notation and the analysis of movement behavior of humans in face-to-face communication. For him an important requirement had to be met if the method was to be successful: the notation of human movement behavior had to be purely descriptive. In his view, movement behavior had to be notated in such a way that "motion should be regarded as data rather than explanation" (pp.10). He thus calls for caution, especially to Psychologists (pp.24), to avoid the contamination of motion data by interpreting it. To point to the dangers attached to such contamination, he refers to the disastrous German history of Expression Psychology and states: "Much of the earlier material is frankly racist" (pp.13).

A central methodological aim of Birdwhistell's work was to connect this purely descriptive notation of *spatial* human movement behavior with the *time* it takes to perform these movements in a *bivariate* notation system. To reach this goal, he came up with a brilliantly simple idea to connect the notation of communicative events during motion behavior with notation of the alphabetic language, which inherently contains a temporal component (Fig. 1).

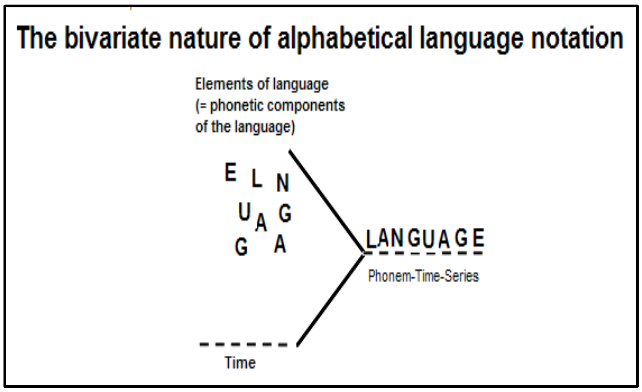

Fig. 1: The bivariate (Phonem-Time) notation of alphabetic language. In writing down words, spoken language is broken down into the phonetic (grc. elements) and temporal components. By the same token, it is possible to reproduce elements, phonemes or letters of the language in their correct or original temporal sequence in the process of reading from left to right.

This means that for Birdwhistell the transcribed speech behavior of observed persons also forms- apart from information about the verbal content- a *temporal* reference for the entire time lapsed during the communication process. To analyse the communicative events, Birdwhistell filmed the various situations. In the first step, the produced film material was used to transcribe the words spoken by the persons. With this speech transcription, Birdwhistell created the first part of his behavior notation. Now a notation, describing the motion behavior of the actors, was still lacking. For this purpose, he drew a series of pictogram-like symbols, whose meanings he wrote down into a code or meaning index. These symbols, which he called "Kineme," for him presented the smallest descriptive movement units (Fig.2).

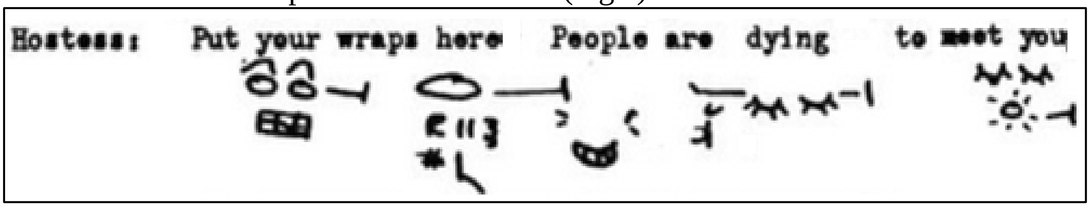

Fig. 2: Section from Birdwhistell's code, in which the symbols he used ("Kineme") and their descriptive meanings were listed in the fashion of a lexicon.

During a complete or partial review of the film material, he now draws the appropriate symbols for the different observed movements under the various places in the transcribed text where the movements accur and has thus additionally marked the point in time or time space in which movements were performed (Fig.3).

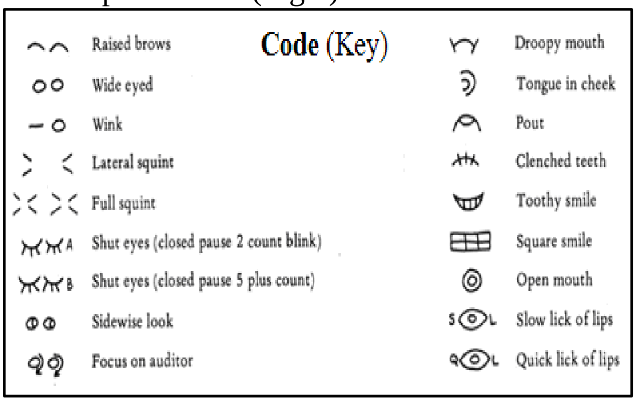

Fig. 3: Birdwhistell`s bivariate Notation(Speech-Time and Positions of Human Bodyparts) of visible human behavior at the hand of an extract from a "hostess-guest-event." Description of hostess motion-behavior: She smiled at him, lips pulled back from clenched teeth. Then, as she indicated where he should put his coat, she dropped her face momentarily into an expressionless pose. She smiled toothily again, opened, and shut her eyes again as she pointed to the guest with her lips. (pp.29-30)

Birdwhistell, who expanded the description of motion behavior to include the whole human body, also expanded his bivariate notation with additional signs which made the description of motion behavior significantly more precise. Above the speech notation, he added numbers, arches, arrows, angles, etc. to a) indicate at which angle- noted in approximated 15 degree steps - various body parts are positioned (pp. 50) and b) in which of the three spatial dimensions- indicated in anatomical direction descriptions (e.g. pp.37) - this positioning accured (e.g. pp.50-51). Below the same example as above, with the complete set of symbols (Fig.4).

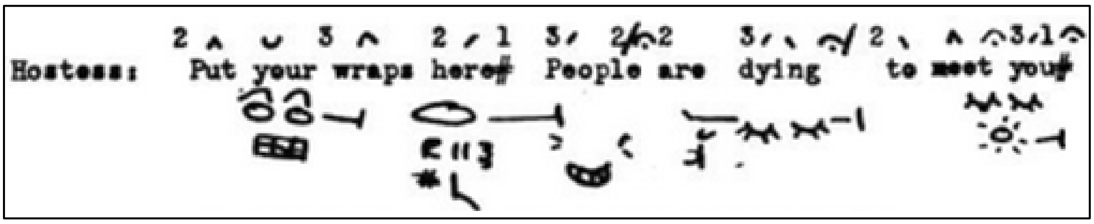

Fig. 4: Birdwhistell`s behavior notation (see example above in Fig.3) with the complete set of symbols

Summary:

1. The movement description by means of a phonem-time notation is based on a code system in which the signs used (symbols or "kineme") are made explicit. 2. Information of movement behavior is not gathered at the time of direct observation, but is later transcribed frame by frame with the aid of film recordings. 3. Great care was taken to make sure that the notation was purely descriptive and it was warned against the possible danger of bias associated with diffusing description with interpretation. 4. All visible body parts were incorporated into the behavior notation. 5. Approximate angles for body part positioning were notated. 6. All three spatial dimensions were named in the description. 7. The scale or calculation level of notated data: Ordinally scaled.

Conclusion: Without a doubt, the quality of a descriptive behavior notation is primarily recognizable by a) how high-resoluted, precise and detailed the original observation can be reconstructed by the notated data b) how, or to which extent, the notation is contaminated by (mostly biased) interpretation. In this respect, Birdwhistell presented no objective tests for the effectiveness of his method. The meticulously constructed and well thought-through symbols ("kineme") could also have an alienating effect on contemporary observers. However, the combined connection between the approximated angles and information on the three spatial dimensions do allow significant possibilities for description of human movements with which a great number of human movements could be generally represented on the level of an ordinal scale. Yet, two points of criticism against Birdwhistell's method from the perspective of later developments are to be emphasized:

1. Birdwhistell`s attempt to create a purely descriptive system of notation with these symbols was not entirely successful. The descriptions of the meanings of the symbols contained in the code were often unclear and to a great extent open for interpretation by the user of the code. What is meant by a "normal" mouth position or "shaking of the head," when is a mouth position "droopy," are "feet" indeed been "scraped," etc. remain open to the free- and thus: biased- interpretation of the observer.

2. Furthermore, the time information as notated over the alphabetical speech notation as a temporal component, which is meant to record when the motion behavior took place, is imprecise in Birdwhistell's original notation. This is caused by the fact that words and single syllables are spoken at different lengths by different persons. This also applies for speech pauses, for example, the duration of which could variate significantly from speaker to speaker. These example in themselves illustrate that an event, in itself temporally dependent, like the spoken word or its alphabetic notation, can by no means serve as an objective time reference or

a tool for timing in a notation of other events and must thus always remain imprecise. In short: The time reference or time indicator itself cannot be open to variation. Only time itself or its objective measurement does not vary and therefore has the ability to be used as a reference for precisely indicating the duration of events.

Adam Kendon`s methodological progress

The Psychologist Adam Kendon, who had studied at the universities of Oxford and Cambridge(b. London 1934), in 1967 published his research in his work, “Some Functions of Gaze-Direction in Social Interaction“ (Kendon, 1967), which also dealt with visible human behavior under the larger theme of Human Communication. With his own bivariate space-time notation of human movement behavior, in which he enhanced the method with two innovations, he introduced sustainable progress. The first innovation deals with the appearance of his notation and the second with the way in which movement behavior is temporally captured.

The new appearance of the bivariate behavior notation: For centuries, probably even since the Babylonian advanced culture, where it was used for creating the calender (2000 B.C.), mathematical figures and other symbols has been noted in *tables*, consisting of rows and columns. This order-giving tabulation was also utilized by Kendon in his bivariate notation.

The new way of measuring time: Kendon did not use the imprecise alphabetical speech notation as a time reference, but introduced objective time measurement, in that he divided the lapse of time during his observations into equal time intervals. The result, in combination with his use of a new appearance of the bivariate notation, was a *spatial-temporal table*. Each new row in the table represented a new time interval, whereas each column represented the spatial positioning of the body parts of the observed person. For describing the spatial position of body parts, Kendon- just as was the case with Birdwhistell- used pictogram-like symbols (Fig.5).

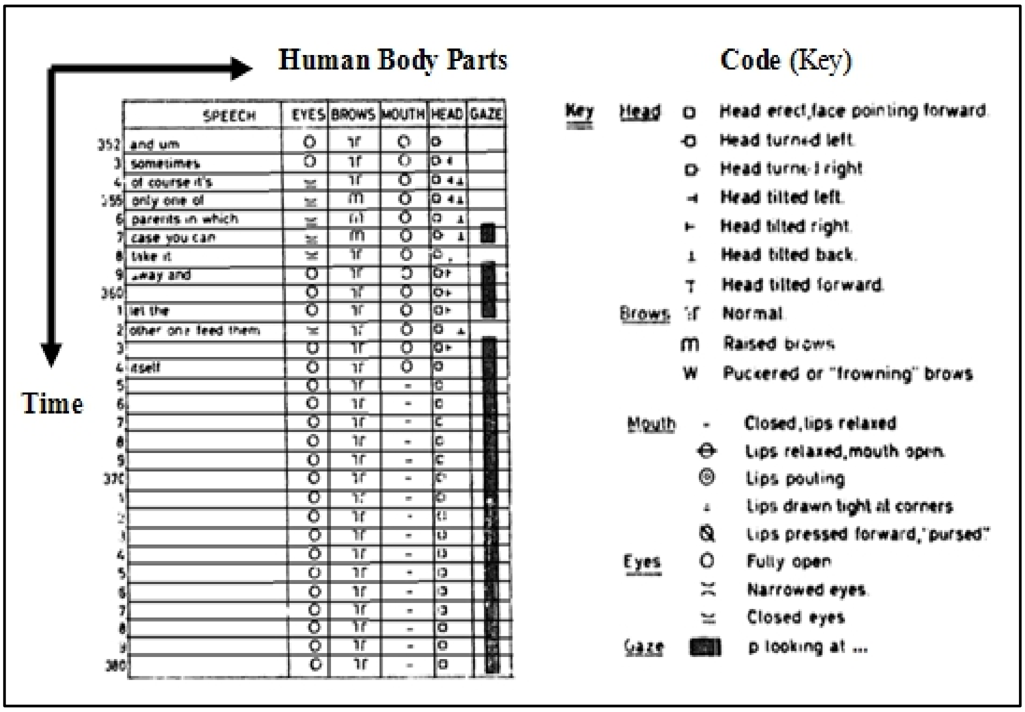

Fig. 5: Left-hand side of the diagram: Kendon`s bivariate notation (Time: half-second step each row - Positions of human body parts in columns: Eyes, eyebrows, mouth, head) of visible human behavior as a sample from a conversation setting. On the left-hand edge of each row, numbers can be seen, which indicate intervals of half-a-second each.(Note: The vertical lines in the table are not original, but added by this author so as to clearly explain the rows). Right-hand side of the diagram: Extract for the Code (Key) used by Kendon, containing the symbols and explanations of its meanings (pp.30-32).

Conclusion

1. Kendon was one of the first to develop a bivariate notation (time positions of human body parts) of visible human behavior in which the objective time measurement is used as a reference for the temporal demarcation of spatial movement behavior. This allowed the precise temporal description of the observed behavior. 2. He gave his notation the organized and structured appearance of a table, according to rows (time intervals) and columns (individual human body parts). 3. The position or movement descriptions are- as is the case with Birdwhistell- based upon a code system, in which the signs (symbols) used are explicated. 4. Observed behavior is not- as is also the case with Birdwhistell- noted during direct observation, but later transcribed, frame by frame, with the aid of film recordings. 5. Care was taken that the transcription was purely descriptive. 6. The scale or measurement level of the noted data: Ordinally scaled.

Conclusion: The new table format and the use of objective time measurement present sustainable progress for the bivariate spatial-temporal notation of visible human behavior. Apart from the clear arrangement of such notations in a table format, time periods of observation could now be precisely defined at will, with the aid of the used time intervals. Forthwith, observed movement behavior could be described in high definition as regards to its temporal progression. On the other hand, Kendal's notation is not free of bias, because it is also here not possible to work purely descriptive. In the notation code, specific explanations of symbols are also open to free interpretation to a large degree, because what "relaxed" lips, "raised" eyebrows or "sunken" head, etc., look like, are left to the interpretation of the observer. The latter problem- that the symbols along with the explanations of their meanings, or the code system itself, present the decisive weakness of the bivariate spatial-temporal notation of movement behavior- could have become clearly recognizable in 1967. On this basis, and the emergence of video recorders and computers in research laboratories, it could realistically have been expected that further methodological advances would follow, which would have solved the "weak point of the code"- dilemma in the decades following: the 1970s and the 1980s. That this was however not achieved, is clearly illustrated at the hand of the following brief description of a project which launched a last attempt to salvage the code system by way of a spurious solution.

The last code system

In 1981, under the theme of Human Communication, a bivariate spatial-temporal notation of visible human movement behavior was published, which the authors titled the "Berner System" (Frey et.al, 1981). In introducing the "new methodological basis" (pp.203) and the basic function principles for the "Berner System," the principle of the bivariate phonem-time notation of the alphabetical speech notation is explained. Though the self-same method had already been used by Ray Birdwhistell 30 years prior for the notation of movement behavior, the authors made no mention to the trailblazing work of the said pioneer, neither by name, nor in reference (pp.210-212). Instead- as if the work of Birdwhistell had never existed- it is further noted that "Although the application of the principles of timeline notation for coding speech behavior has long been a given, literature in no way seems to be clear on whether this principle can also be made useful for the transcription of complex movement events." (pp.212). The authors- as we will see below- go on to construct their spatial-temporal notation for the "Berner System," by organizing it in rows (time intervals) and columns (body parts), thereby using objective time measurement for giving the time, just as Kendon had done some 14 years prior (see above), again without quoting his works or giving him personal credit (pp.224). Notwithstanding how the authors deem fit to honour the achievements of peer researchers in a way unusual in scientific circles, a statement can be read in a later publication of one of the main authors, the Psychologist Frey, that "with the Berner System in the early

1980s, a non-semantic notation method could be utilized for the first time"(Frey, 1999). "Non-semantic" is supposed to mean "without any relation to meaning on a level of content"(Frey, 1999). For methodology, this means that the "Berner System" lays claim to allowing purely descriptive notations. Should this claim hold true, the above-mentioned "weak point of the code," which also presents itself in the notations of Birdwhistell and Kendon, would have been solved. In looking at the spatial-time notation of the "Berner System," one notices that the symbols, as used by Birdwhistell and Kendon, were replaced by numbers (Fig.6, left side of the diagram).

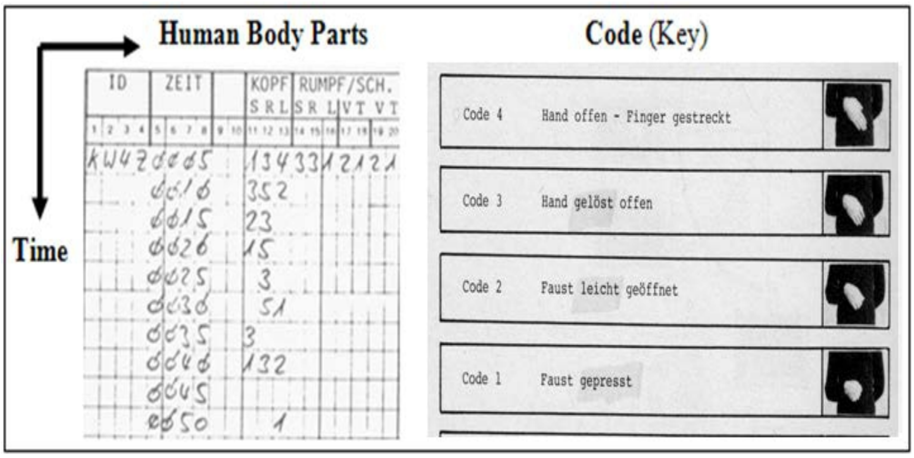

Fig. 6: Left side of the diagram: The bivariate notation(Time: half-second steps each row; Positions of Human Body Parts in columns: Kopf = Head, Rumpf = Trunk) of visible human behavior according to the "Berner System," as a sample from a conversation setting.

Right side of the diagram: Here a sample of the utilized, so-called non-semantic Code (Key) for the explanation of the notation of the numbers used can be seen, as explained by the example of hand positions: Code 4 = hand open/fingers stretched/ Code 3 = hand relaxed open/ Code 2 = fist slightly open/Code 1 = fist clenched (pp.224, 230).

At the first glance, these numbers suggest mathematical precision, as if we are dealing with metric values. Further investigation reveals that the numbers written into the columns for body parts (e.g. Head, Trunk), are nothing but *code numbers*. These code numbers, which the authors borrowed from the previously developed facial coding system by Ekman et al., FAC (Ekman et.al., 1976), now refer to the code of the "Berner System." In this code, code numbers can be found, with explanations and small photos, on which mostly quite unclear body positions are shown (Fig.6, right side of the diagram). The code numbers thus represent that which is listed in the code. This means, that, instead of using the "Berner System" for spatial-temporal notation, one could just as well add in a description and photo, when an observer who works with this code believes to have recognised the body position of the observed person that matches the position described therein. Yet, how should an observer decide, if he or she reads "hand relaxed open," "fist slightly open," "fist clenched," "head sharply turned," "trunk strongly reclined," "the upper arm touches the upper body perhaps," in the descriptions? What do "clenched," "slightly," "sharply", "strongly" ,"reclined," or even "perhaps," look like and from which point in time and which not this situation has existed? It follows that the observer working with this code is expected to perform significant independent interpretative tasks, which renders it in no way "non-semantic," and as a consequence offers no description free of bias. The weakness of the code, as described above in the context of the works of Birdwhistell and Kendon, thus also remained unsolved by the "Berner System."

Conclusion: Regardless of the research effort laid claim to by the authors, another question arises: Which *innovative methodological own achievement*, apostrophized as a "new methodological basis" (pp.203) can be drawn from the "Berner System?" One detail of the

"Berner System" comes to light for the first time: There is a separate column entry in the three spatial dimensions for each of the notated body parts. Thus it can be seen on the left side of the diagram in Fig. 6 above, that under "Head," lateral, rotational and sagital spheres have each been added with a separate column, denoted with "S," "L," and "R" in the notation. This new methodological detail introduced by the "Berner System," could however barely be regarded as a "new methodological basis,"(pp. 203) on an objective level.

The decisive methodological further development in the bivariate notation of movement behavior was heralded at the end of the 1990s, when a disconnection to the code system accured.

Angle Measurement instead of Code Numbers: The *Scriptanimation*

The Psychologist, Guido Kempter, developed his own method called *Scriptanimation* and introduced it in 1999 (Kempter, 1999). The method in question is a 2D/3D computer-assisted animation process, which is first and foremost aimed at allowing observers to capture the movement behavior of persons in a purely descriptive fashion. The starting point of this process is a 2D video recording of the movement behavior of persons from the frontal perspective. The visible behavior of the persons as seen on the video (25 FPS), is then transfered, image by image, onto a computer-steerable, sixteen-part 3D computer model with the appearance of a stick figure. Each of the sixteen parts of this 3D model is steerable in all three spatial dimensions over the user interface (GUI) of the software (Fig. 7).

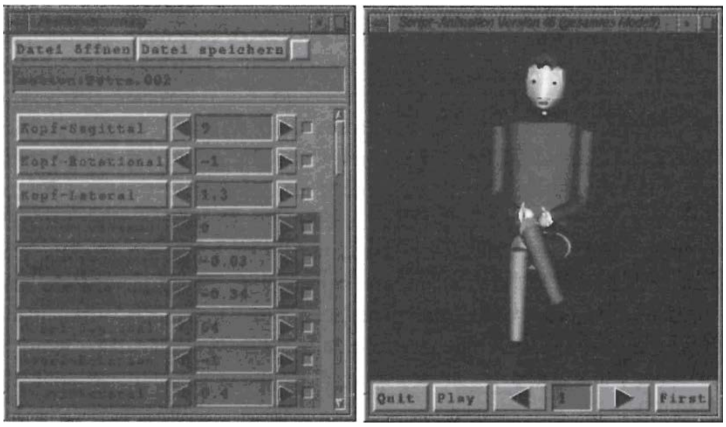

Fig. 7: The user interface (GUI), visible on the computer screen, for steering the sixteen part 3D stick figure in all three spatial dimensions (pp.108)

The positions generated with the 3D stick figure are entered into a program-internal, table format, which is arranged according to time intervals (rows) and the spatial position of each of the sixteen stick figure parts (columns) as angle measurements and angle values (Fig.8). With the use of this spatial-temporal table, or position-time notation (= script), the same 3D figure with which the angle values were generated and written into the notation, is reanimated.

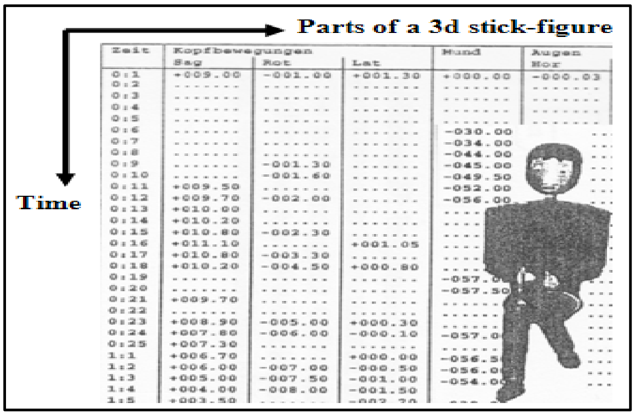

Fig. 8: The bivariate notation (Time: 25 FPS / Positions of 3D Stick-Figure Parts) of human movement behavior, using a 3D compter model in the shape of a stick figure, calculated in angle values. Each figure part is represented in the three spacial dimensions and shown in separate columns (pp.104).

With this method of notation, the “weak point of the code” has been eliminated. There is no code, and therefore also no open interpretation of “explanations and circumscriptions,” as not only found in Birdwhistell and Kendon, but also the “Berner System” and Ekman et al. This notation is purely descriptive and thus free of bias. Here the observer, or the person positioning the 3D stick figure, is only expected to be visually descerning. Further advantages of this method: The movements are temporally as well as spatially dated in high definition and precise detail. Through image to image captured values, negative and positive movement acceleration can be precisely recorded and reanimated. The latter presents an additional achievement, which has not been possible for other animation procedures (motion capture, keyframe animation, etc.) to achieve up to that point in time. The date is interval-scaled and opens a multitude of possibilities for mathematical analysis, which ordinally scaled data obtained in the past could not provide.

The important progress presented by *Scriptanimation* formed a basis for new possibilities for development and contributed towards further improvements in the bivariate notation of movement behavior. In this respect, the first question poses itself: What is the *quality* of the angle values generated with the use of *Scriptanimation*? To what degree is it possible to create angle values with the 3D stick figure, which realistically reflect *human* movement? High consistency with human movements can only be achieved in the head movements of the stick figure. In the case of all other movements made by the figure, the observer could possibly create the illusion of close similarities with human movements, but viewed objectively, these movements have only little in common with real human movements. The reason for this lies in the construction of the 3D figure. It is plain to see that the figure has no shoulders, its torso is a lacklustre cone, its hands are incomplete, etc. From this follows that figures constructed in such a way are on the one hand not able to a) produce realistic human movement, and, on the other hand, produce movement which humans b) do not make at all. From these two facts it necessarily follows that the angle values cannot reflect that of the movements of the observed persons. Moreover, it follows that a majority of the measured values needed for psychological analyses and problem-solving cannot be obtained from these stick figures. The solution to this problem is obvious: Instead of the stick figure, the observer should be able to position a computer model in such a way as to reconstruct realistic movement possibilities of humans, and with it reproduce the real angle values in the notation.

Since the observer uses a computer programme for the notation of visual behavior, the next question as to the user-friendliness of such a notation software arises. This largely determines whether and to which extent a user would be willing and able to perform the task of observation. Learning how to use *Scriptanimation* demands a long period of training, the software is quite bulky and, more often than not, leads to frustration on the part of the observer working with it.

Human anatomy and user friendliness: *ScanimFBX*

Building upon the basic idea of *Scriptanimation*, Zysk, Filkov und Feldmann published significant improvements of bivariate notation in the form of their own developed software, *ScanimFBX* (Zysk et.al., 2013). It presents, as is the case with *Scriptanimation*, a 2D/3D computer-supported animation process aimed primarily at enabling observers to capture the movement behavior of persons in a purely descriptive way. The starting point of this procedure are two video recordings on which the movement behavior of persons are filmed from both the frontal and lateral perspectives and presented on the user interface of the *ScanimFBX*. The observed movement on the video is transfered by the observer on to a 3D humanoid computer character- specially designed for this purpose- which has the appearance, proportions and the realistic functional-anatomical movement possibilities of humans. The observer positions each body part of the character in exactly the way he or she sees the person on the video, frame for frame (1-100 FPS). Each body part of the 3D character is steerable in all three spatial dimensions over the user interface (GUI) of the software (Fig.9).

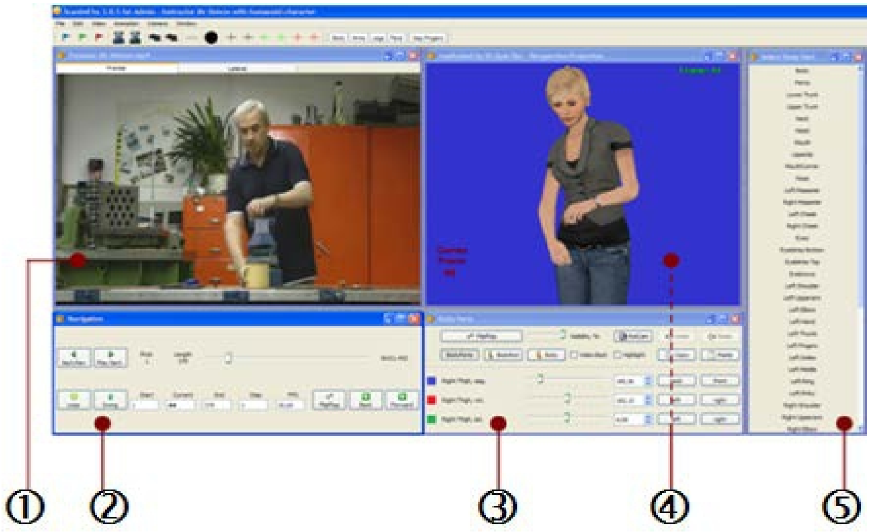

Fig. 9: Screenshot of *ScanimFBX* GUI (Windows-Platform): 1. Video-Window with frontal view of the original behavior (video-window for the lateral view is behind this window and can be activated by mouse-click) 2. Window for steering the video and start/stop playing animation. 3. Window for anatomical limited steering positions of the whole body and bodyparts. 4. Character-Window with female 3D humanoid character. 5. Body parts window with body parts list for selecting and activating body parts by mouse-click. (pp.57)

The positions generated with the 3D humanoid character are written with limited angle values into a program-internal, executable, table-format notation, ordered by time intervals (rows) and spatial positioning of the individual body parts (columns). *Limited* means that the body parts of the character can only move within the restrictive framework of angles which also apply for humans. For example, the head of the character can only be moved to the right or to the left as far as it is possible for humans to do the same. Thus it is also impossible for the operator to make the mistake of positioning the body parts of the character beyond the realistic movement angle. As a safeguard of the angle limitation, the operability of the control elements visible on the user interface has been designed in such a way as to make over-steering impossible. (Fig.9, 3). Through this limitation, the generated angle values have an absolute zero point, so that the measurement level of the data is ratio-scaled, and as such allows all mathematical operations with the data. Thanks to this user-friendly software, it is possible for computer laypersons (n=50) to, without exception and after a short period of introduction, be able to write down a program-internal bivariate spatial-temporal notation with correct functional-anatomical angle values of the movements of observed persons, in high resolution, with precision and virtually without mistakes (Fig. 10).

Body Parts of an anatomical 3d humanoid character

Time

Frame	Body, horizor	Body, vertical	Body, in/out	Pelvis, sag.	Pelvis, rot.	Pelvis, lat.	Lower Trunk,
1	0	92,329	0	-90			-0,931
2	0	92,329	-0,016	-90			-1,046
3	0	92,329	-0,035	-90			-1,192
4	0	92,329	-0,056	-90			-1,359
5	0	92,329	-0,078	-90			-1,52
6	0	92,329	-0,101	-90			-1,654
7	0	92,329	-0,126	-90			-1,751
8	0	92,329	-0,149	-90			-1,81
9	0	92,329	-0,167	-90			-1,832
10	0	92,329	-0,18	-90			-1,823
11	0	92,329	-0,189	-90			-1,791
12	0	92,329	-0,194	-90			-1,737
13	0	92,329	-0,197	-90			-1,652
14	0	92,329	-0,199	-90			-1,516
15	0	92,329	-0,2	-90			-1,311
16	0	92,329	-0,2	-90			-1,03
17	0	92,329	-0,198	-90			-0,678
18	0	92,329	-0,194	-90			-0,268
19	0	92,329	-0,186	-90			0,193
20	0	92,329	-0,174	-90			0,719
21	0	92,329	-0,157	-90			1,338
22	0	92,329	-0,135	-90			2,073

Fig. 10: The bivariate notation (Time: 1-100 FPS; Positions of Body Parts of an anatomical 3D humanoid character) visible human behavior by using an anatomical 3D humanoid computer model, entered with functional-anatomical limited angle degrees.

With this spatial-temporal notation, both the 3D character with which the angle values where created, or another 3D humanoid character with a different appearance can be reanimated by retargeting the same values. The movements remain absolutly natural.

Conclusion

That it is also possible for the field of Psychology to today acquire imperical knowledge about visible human behavior on the level of the methodology of the Natural Sciences with regards to precise details, high resolution and pure description, is here presented at the hand of a brief overview of five research efforts, which shows the progress made in the development of the *bivariate notation* of visible human behavior from its early pioneering stages up to the current state of affairs. The examined historical timespan of this methodological development reaches back to the irresponsible imputation of Expression Psychology and leads up to the unbiased descriptive metrical behavior measurement with 3D humanoid computer characters. A decades-long persistence of weaknesses in *data mining* must be conceded to in such an essential field of Psychology. It has however gradually gathered strength, which has long become a trademark in the field of data analysis and its experimental methodology. These developments have only been made possible with the help of modern computer technology, fortunately enabling also computer laypersons to work in this field and making exciting future progress all the more probable.

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