Human Development 2002;45:167–173

Human Development

Variations on Dynamic Variations

Henderien Steenbeek Paul van Geert

Department of Psychology, The Heymans Institute, Universtiy of Groningen, Groningen, The Netherlands

Key Words
Coherence · Dyadic interaction · Dynamic systems · Fuzziness · Modeling · Peer-interaction · Play · Responsiveness · Variability

Yan and Fisher emphasize the importance of studying variability, in order to 'analyze processes of change in learning and development (p. 2)'. By studying patterns of variations in cognitive data, one can 'reveal fundamental dynamic mechanisms'. Knowing more about these mechanisms means getting a grip on the important building blocks that contribute to the processes of change.

As a tool to study the *processes of change*, they use a framework that combines ideas of development, variation and dynamic systems. Concepts from dynamic systems theory such as that of mutually influencing variables, nonlinear dynamics, and the importance of chance [Van Geert, 1994a] are used to obtain a better understanding of the developmental process under study. This approach brings particular research methods, including the necessity to take a closer look at data of individuals separately.

In our commentary, we will address three points. The first is that the approach advocated by Yan and Fischer can and in fact should be generalized to the study of processes in general, involving both long term and short term change. Second, we will point at an additional form of variation, which relates to the issues of observer agreement and the intrinsic fuzziness or vagueness of the properties of the developmental levels involved. Third, we will briefly address the importance of dynamic modeling as a way to obtain a better understanding of the theories underlying the study of dynamic processes, in particular dynamic variation.

KARGER

Fax + 41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

0018–716X/02/0453–0167$18.50/0

Accessible online at:
www.karger.com/journals/hde

Paul C. van Geert, Department of Psychology
The Heymans Institute, Grote Kruisstraat 2/1
NL–9712 TS Groningen (The Netherlands)
Tel. +31 50 363 6309, Fax +31 50 363 6304
E-Mail vangeert@inn.nl

Generalizing the Dynamic Variation Approach: An Example from the Study of Social Interaction

In their investigation of dynamic variations in adult cognitive development, Yan and Fischer call upon three 'patterns in micro developmental pathways' to study important growth processes: (1) range of variation in level; (2) kind of pathway shown, and (3) asynchrony due to task and domain.

In our view, the 'patterns' that reveal variability, can – and should be – generalized to other areas of development, such as social development. We illustrate this point with some observations from our study of dyadic interaction in a play situation. The broader context of our work is dynamic systems theory. Important research using this theory in regard to social and emotional development is, among others, done by Fogel [1993] and Lewis and Granic [2000].

The aim of our study is to determine whether there are differences in the interaction patterns of popular and rejected children. Differences should, according to previous studies [Black and Logan, 1995; Hazen and Black, 1989], be shown in emotional expressions and in mutual responsiveness in interaction with parents. In accordance with studies that link the interaction of a child with a parent to the interaction of that same child with a peer [Russell, 1998; Kahen, Katz and Gottman, 1994], we started with the expectation to find differences between popular and rejected children in interactions with peers.

We studied 24 dyads of children in grade 1 in a small town in the Netherlands. We first determined the sociometric status of the children by means of a rating procedure and a computer program that analyzes the data [SS-rat, Maassen, 1996]. The children were videotaped during a 10-minute play session, which involved either a dyad of two same-sex children or a child and his/her parent. Each peer dyad consisted of a popular or a rejected child, coupled with a neutral play-partner with an average status. The 'control' group consisted of dyads of children of the same average status. Three repeated measurements (of sociometric status and videotapes of the interactions) were made in four months.

It is obvious that the interaction patterns we studied are dynamic and variable by nature: if they do not vary over the course of a play session, there is probably no action, let alone interaction. The variability we are interested in is specified at a different level than that of Yan and Fischer: how variable are the properties of the interaction patterns themselves? For instance, how variable is the level of mutual responsiveness in the interaction?

In addition, are the 'independent' variables, more precisely the child's sociometric status level, stable properties of the children, or are they themselves dynamically variable properties? The sociometric status of a child is a product of a dynamic process among children in the same class, and as such, its variation is a direct reflection of the processes that bring such statuses about. Even Moreno, the founding father of sociometric status research, emphasized the dynamic nature of groups and sociometric measures [Moreno, 1943]. According to Cillessen, 'this dynamic nature is reflected in the change and stability of sociometric measures over time' [Cillessen, 2000, p. 2]. As far as variability is concerned, there is no difference between a property such as sociometric status and a property such as Yan and Fischer's cognitive skill levels.

In this article, we will confine ourselves to discussing one aspect of the interaction: mutual responsiveness during interaction. We concentrate on short-term variability, in the data of two children during one play session.

We used a scale for scoring mutual responsiveness [based on De Koeijer, 1997; Gerrits and Steenbeek, 2000], which consists of five levels (from 1 to 5). Mutual responsiveness can be seen in sharing turns – verbal or nonverbal – and in focus, showing in the direction of gaze. Level one, which is called 'totally coherent' represents the highest level of mutual responsiveness, characterized by at least three shared turns. Level five, which is called 'totally incoherent' is the lowest level of mutual responsiveness, which shows in just one turn, (not followed by a reaction) with (largely) no shared focus, or no turns at all, with (largely) no shared focus.

We examined inter-observer reliability using an alternative agreement measure that specifies the observed agreement in comparison with simulated agreement-by-chance [van Geert, 2001]. The partial agreement we obtained was 0.76 [Resner, 2000]. The simulation of chance agreement showed that the probability that this agreement was caused by chance is negligible. Later we will discuss partial agreement as a means to arrive at yet another level of variability, related to varying levels of vagueness or fuzziness of the observed levels or categories.

Pattern 1: Range of Variation in Level

When the data are represented in a graph with time on the x-axis and the level of mutual responsiveness on the y-axis, we can see that all dyads fluctuated between distinct levels of mutual responsiveness. This is no surprise, because one can expect that variability in mutual responsiveness is a central property of normal interaction. It then becomes interesting to determine on what level the 'attractor' lies. The attractor level reveals itself by its high amount of occurrence and a regular return to this level after a fluctuation, as a kind of 'basis level' of the interaction. This appears to be level 2, in which the children showed either three shared turns and mostly shared focus, or two shared turns with shared focus all the time[1].

However, the existence of such an attractor level does not imply that this is the dyad's 'true' level. In fact, comparable to Yan and Fischer's notion of fluctuation between an upper and a lower cognitive level, we found that dyads vary between levels of coherence. More important is that dyads differ in their range-width. Some dyads stayed mostly in the lowest regions of the scale, others mostly in the highest. Some dyads varied a lot, ranging from a lot of time in the highest to a lot of time in the lowest level of mutual responsiveness.

Pattern 2: Kind of Pathway Shown

Our study differs from the study of Yan and Fischer with regard to the role of variation. The expected variability depends on the dimension or variable one is interested in and on the accompanying function of variability. In their type of task, Yan and Fischer could expect to find an average, more or less linear progressive trend, due to learning effects, which are of course intended to occur in a learning-teaching context. In our interaction data, we did not expect a learning effect, but rather a specific amount of variability, because this is inherent to normal interaction. Nonetheless, *differences* in

[1] We used time sampling over intervals of ten seconds. Each interval is characterized by its dominant level.

variation can be very informative, for instance because they relate to different social statuses or because they serve different functions in the ongoing interaction process.

Our investigation so far has scored dyads, comparable with the studies of Granott [1993], who has shown that dynamic skill theory can easily be applied to dyads. We began with a simple overall measure, namely the total amount of time that each dyad showed a particular level of mutual responsiveness, and compared the averages of the different status groups by means of analysis of variance. With this 'traditional' method, we did not find any differences between status groups [Resner, 2000]. Our next step is to examine the variation patterns more closely, in order to get more insight in differences in qualitative aspects of the patterns of interaction. Moreover, by looking at individual children and their contribution to mutual responsiveness, we hope to arrive at a better understanding of the individual dynamics of each separate child.

Just like it is a mistake to treat cognitive skill as uniform and stable, it is also a mistake to treat subjects as if they had one specific level of stable interaction skill. Interaction skills vary in different contexts, with different interaction partners, and are only one of the determining factors that play a role in building the process of dyadic interaction.

Our study differs from the study of Yan and Fischer with regard to the 'goal' of the process under study. The study of Yan and Fischer deals with learning, which has a clear, objective measurable goal; namely to succeed in the task, whereas our study deals with interaction during playing, which has an internally felt, subjective goal: namely to have pleasure and to experience positive emotions [Hughes, 1999]. According to Frijda [1986], emotions are changes in action-readiness that arise as a reaction to events that are relevant for the concerns of the individual. Based on Frijda's ideas, we use concerns as the basis for emotions and behavior. Thus, the player will display particular behaviors and emotions in order to get his concerns realized. The level of realization of the concerns is not only dependent on the nature and intensity of the player's concerns, but also on the player's and the play partner's preceding behavior. This iterative process repeats until the end of the interaction. All the observed variables in the interaction (such as mutual responsiveness) result from these factors, and show fluctuations corresponding with variations in the concerns.

Pattern 3: Asynchrony Due to Task and Domain

We are also in the process of comparing different interaction situations by looking at the same dyads in a cooperative learning session. In both situations interaction is important, and both situations give an opportunity to practice social skills. However, in play, interaction is aimed at achieving a pleasurable interaction, whereas in the more structured cooperative learning situation, joint reasoning to solve the task has to be established. The two children are asked to build figures of blocks. Only one child has the instruction form and the set of blocks is divided over the two children.

We expect to find asynchrony between the play and the cooperative learning situation, partly because the task context evokes different concerns, and partly because the concerns that are also present in the play situation are realized in a different way. For example, already from the beginning, the task forces the children to cooperate, which almost automatically leads to a higher level of mutual responsiveness. Yan and Fischer also subscribe to the importance of the interplay between task specific and individual factors.

Dynamic Variation, Fuzziness and Reliability

In classical measurement theory, a measurement – such as a test score or a categorization – is viewed as the sum of a true value (a property of the source) and an amount of noise or error. Yan and Fischer rightly remark that variation should not be identified with error or noise superposed onto a 'true', static value. However, some of the variation in the signal could still be due to observation error. Fortunately, Fischer's dynamic-skill-theory scale provides a highly reliable way of categorizing cognitive levels (a kappa of 0.94 is reported). Unfortunately, not every scale is as reliable as Yan and Fischer's.

Many psychological phenomena are considerably less specific and confined than cognitive skill levels. With mutual responsiveness, even highly trained observers could not exceed a certain level of observer agreement, which was well below Yan and Fischer's kappa of 0.94, namely a Cohen's kappa of 0.53[2] [Resner, 2000]. In another study, relating to young children's use of prepositions, we obtained a comparable ceiling level in the agreement reached by two thoroughly trained observers [van Dijk and van Geert, submitted].

In our view, the ceiling level should not be explained by a lack of information or precision in the data, leading to a misjudgment of the true category by at least one observer. We argue that many categories referring to various levels or aspects of behavior are inherently vague or fuzzy, for instance early prepositions, emotions or mutual responsiveness [van Dijk and van Geert, submitted; van Geert, 2001].

Fuzziness implies that a category applies to an observation to a certain degree. If the categories are based on a more or less arbitrary division of a continuous scale into distinct categories – which is the case in our use of a mutual responsiveness variable – such vagueness or fuzziness is easy to understand, in that there exists no qualitative boundary between 'totally coherent' and 'largely coherent', for instance.

However, fuzziness applies in principle to any category. We expect that Yan and Fischer's skill levels – which represent qualitatively different classes of cognitive skills – will show a comparable variation in fuzziness or 'crispness'. That is, we expect that there will be cognitive actions that are prototypical single representations, but we also expect that there exist actions that are 'basically' single representations, but 'are almost' representational mappings, to give just one example. This form of qualitative variability is likely to occur regularly. It may have an important functional value, for instance by allowing a form of bridging between a current optimal level and a newly developing, more complex one.

Empirically, fuzzy categories may be discovered by exploring inter-observer disagreement (provided the observers have been thoroughly trained). In our study, observer disagreement was used to estimate the fuzziness of the mutual responsiveness categories. From this point of view, it is not advisable to 'over-train' observers because the agreement they successively achieve might be artificial.

[2] Note that the Kappa may become very low if the marginal frequencies are highly skewed, for instance if level 2 occurs 80% of the time. In addition, the standard Kappa does not distinguish degrees of disagreement, a level 1/level 2 difference contributes as much as a level 1/level 5 difference.

Modeling the Process of Interaction

The notions of dynamic variation and scalloping that feature prominently in Yan and Fischer's approach refer to highly nonlinear processes. In our study of social interaction we expect to find comparable nonlinearities. Models featuring nonlinear components are often hard to understand. In linear, additive models, the outcomes of particular constellations of independent variables can be anticipated by simple equations, for instance in the form of regression models. An approach such as Yan and Fischer's, but also our model of social interaction, refers to iterative processes, i.e. every next step in the process is understood as a function of its preceding step. Such models can often only be understood if they are actually modeled as iterative processes, that is, if the time-course of the process is simulated.

We attempt to generate a dynamic systems model, based on iterative steps, that produces different patterns of interaction typical for children of different sociometric status, especially popular and rejected children.

An important requirement for our model is that it is capable of generating the *kind* of patterns observed in the real-life process of interaction. In order to get a grip on the intra- and inter-individual variability of the data of the individual children, we particularly look at qualitative characteristics of the patterns described above, as suggested in the article of Yan and Fischer. By comparing these qualitative characteristics of patterns of both the empirical data and the model, we have a good tool for obtaining information about the 'fit' between the model and real life on a short-term (one play-session), and 'middle-long' (one-and-a-half month) time interval. These intervals are of the same order of magnitude as those studied in microdevelopment.

Dynamic modeling primarily serves a conceptual goal, showing whether a conceptual model containing nonlinear relationships indeed does what it claims to do. For instance, we believe that differences in concerns generate a good deal of the observed variability in social interaction (same amount, number of fluctuations etc.). A model that might eventually explain the kind of process studied by Yan and Fischer could be based on a Vygotskyan approach, involving the dynamics between cognitive levels instantiated in the actions of a teacher and the cognitive levels of the actions of a learner [see Yan, 2000; van Geert, 1994b].

Conclusion: Analyzing Dynamic Processes

In psychology, the almost universal inclination towards taking averages within and between subjects has led to an unfortunate neglect of an important source of information about processes of change, namely variation. Yan and Fischer have argued that variation is a key feature of the process of cognitive (micro) development, not only in children but also in adulthood. In our article, we have tried to extend their viewpoint to the study of dynamic processes in general by applying the notion of patterns in micro developmental pathways to the field of social interaction in children and (micro developmental) changes in social interaction.

Adding to the points made by Yan and Fischer, we argued that the function, form and consequences of variation depend on the nature of the variables and processes studied. Moreover, we assert that the variability depends on the fact that the processes under study are action processes, which are determined by the person's concerns and emotions and by the specific action context. We also discussed another form of variation, which is variation in the prototypicality or fuzziness of the categories or levels involved in a process. Finally, we argued that, since notions such as variability introduce strongly nonlinear relationships, dynamic modeling is an important tool for obtaining a better understanding of the possible empirical implications of our conceptual frameworks.

References

Black , B., and Logan, A. (1995). Links between communication patterns in mother-child, father-child, and child-peer interactions and children's social status. *Child Development. 66,* 255–271.

Cillessen, A.H.N., and Bukowski, W. (2000). *Recent advances in the measurement of acceptance and rejection in the peer system.* San Francisco: Jossey-Bass.

De Koeijer, I. (2001). *Peer acceptance, parent-child fantasy play interactions, and subjective experience of the self-in-relation; a study of 4- to 5-year-old children.* Veenendaal, the Netherlands: Universal Press.

Fogel, A. (1993). *Developing through relationships; origins of communication, self and culture.* New York: Harvester Wheatsheaf.

Frijda, N.H. (1986). The emotions. Studies in emotion and social interaction. Cambridge University Press: Cambridge, UK.

Gerrits, M., and Steenbeek, H. (2000). *Revision of the scoring-system of mutual responsiveness, based on De Koeijer.* Internal report. University of Utrecht.

Granott, N. (1993). *Patterns of interaction in the co-construction of knowledge: Separate minds, joint effort, and weird creatures.* In: Wozniak, R.H. (Ed.), Fischer, K.W. (1993). *Development in context: Acting and thinking in specific environments.* The Jean Piaget symposium series (p. 183–207). Hillsdale, NJ, US.

Hazen, L., and Black, B. (1989). Preschool peer communication skills: The role of social status and interaction context. *Child Development, 60,* 867–876.

Hughes, F.P. (1999). *Children, play and development.* Boston: Allyn & Bacon.

Lewis, M., and Granic, I. (2000). *Emotion, development, and self-organization; dynamic systems approaches to emotional development.* Cambridge University Press: Cambridge, UK.

Kahen, V., Katz, L.F., and Gottman, J.M. (1994). Linkages between parent-child interaction and conversations of friends. *Social Development, 3*(3), 238–254.

Maassen, G.H., and Landsheer, J.A. (1996). *'SSRAT 2.0: A program for two-dimensional sociometric status determination with rating scales (computer software).* Utrecht, the Netherlands: Maassen and Landsheer.

Moreno, J.L. (1943). 'Sociometry and the cultural order.' *Sociometry, 8,* 307–308.

Resner, I. (2000). *Dyadische interactie tijdens fantasiespel; de relatie tussen coherentie en sociometrische status.* [Dyadic interaction during pretend play]. Unpublished term paper. University of Groningen.

Russell, A, Pettit, G.S., and Mize, J. (1998). Horizontal qualities in parent-child relationships: Parallels with and possible consequences for children's peer relationships. *Developmental Review, 18,* 313–352.

Van Geert, P. (1994a). *Dynamic systems of development: Change between complexity and chaos.* New York: Prentice Hall/Harvester Wheatsheaf.

Van Geert, P. (1994b). Vygotskian dynamics of development. *Human Development, 37*(6), 346–365.

Van Geert, P. (2001). *Interobserver agreement over ranges.* Unpublished manuscript: University of Groningen.

Van Dijk, M., and van Geert, P. (2001). *Ambiguity in Child Language. The problem of inter-observer reliability in ambiguous observation data* (submitted for publication).

Yan, Z. (2000). *Dynamic analysis of microdevelopment in learning a computer program.* Unpublished doctoral dissertation, Harvard Graduate School of Education, Cambridge, MA.