Behavior and Philosophy, 27, 127-145 (1999). © 1999 Cambridge Center for Behavioral Studies

BEHAVIORAL VARIATION: A NEGLECTED ASPECT IN SELECTIONIST THINKING

Siegfried Dewitte
Tom Verguts
University of Leuven, Belgium

ABSTRACT: A selectionist approach to human ontogenetic development relies on three basic processes: variation, selection, and retention. The approach further implies that for adaptive behavior to emerge during development, each of these processes is required. Nevertheless, to date variation has been relatively neglected. Some studies show that behavioral variability is enhanced when the appropriate contingencies are present. Moreover, behavioral variability has been shown to facilitate the acquisition of difficult behaviors in animals (e.g., Neuringer, 1993). In the first part of the present paper, we briefly recapitulate the basic tenets of selectionist psychology and attempt to explore the role of behavioral variability in human behavior. In the second part, its importance in the emergence of intelligence, humor production, and self-regulation is discussed. We present data suggesting that variability enhances intelligent behavior, qualitative humor production and effective self-regulation.

Darwinian evolutionary theory is a strong set of theoretical concepts. It explains complex phenomena by means of simple principles. The theory has been developed in biology but a more abstract version of the theory can be applied to other domains, more specifically, to psychology (Baum, 1994; Cziko, 1995; Dennett, 1995; Donahoe & Palmer, 1994; Hendriks-Jansen, 1996; Pierce & Epling, 1995; Skinner, 1981; Staddon, 1993; Staddon & Simmelhag, 1971). The more abstract version of Darwinism will be referred to as *selectionism.* At this point, it must be emphasized that we will not discuss the natural evolution of our species and the natural selection of behavior (for a recent overview see Buss, Haselton, Shackleford, Bleske, & Wakefield, 1998). The point of this paper is to adopt an evolutionary perspective on ontogenetic development rather than on phylogenetic development.

The abstract version of Darwinian evolutionary theory can be formulated as follows. There is a population of reproducing entities that are not permanent. These entities carry information that determines their features to a certain extent. Some of these features vary in the population. In reproducing, these entities pass on some of

AUTHOR'S NOTE:

Please address all correspondence to: Siegfried Dewitte, Dept. of Psychology, Tiensestraat 102, 3000 Leuven, Belgium (Europe), E-mail: siegfried.dewitte@psy.kuleuven.ac.be. The contribution of the first author was supported by a grant from the Fund for Scientific Research, Flanders, Belgium. We thank Armando Machado, William Baum, Jeremy Pacht, Willy Lens, Johan Wagemans,Wouter Vanhouche, Randy Rzewnicki, Filip Boen, Paul De Boeck and an anonymous reviewer for their thoughtful comments on earlier versions of the paper.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the information they carry to the next generation (with some copying error allowed). External pressures (including for example, scarcity of energy) make these entities compete for their existence. As the entities vary, they will have differential reproductive successes and the population will evolve.

Its application in biology is well known: the finite entities are living individuals, and the features they possess are particular properties (e.g., length, weight, acuity, etc., see Williams, 1992). The information is carried in the genes, and this information partially determines the individuals' features. Under environmental pressure, the individuals have to compete for resources such as food and mates. Their reproductive success is partially determined by their features, and therefore the gene pool of the population will evolve. In an ontogenetical biological perspective, these concepts have also been used to explain the workings of the immune system (Piatelli-Palmarini, 1989) and neuronal evolution in the brain (Edelman, 1992).

In psychology, the application of the general selection principle is less generally accepted, although theorists of several persuasions have pleaded in favor of its applicability (see above). In our view of selectionism, the entities are environment-behavior relations (EBR) in a population of similar but differing EBRs (Donahoe & Palmer, 1994). The population is mainly spread in time, rather than in space. Since EBRs have to compete for operating time, they are considered to be reproduced if they are repeated. The physical basis of this process, analogous to DNA in the biological sphere, is the subject of current research (e.g., Bailey & Kandel, 1995). The general outline of this process is that behavioral selection changes the connection strength of synapses, first temporarily (short-term memory) and if repeated, permanently.

In what follows, 'entities' will be used if the reasoning is believed to apply to any domain in which evolution is present. If we confine ourselves to biology or psychology, we will use individuals and EBRs, respectively. In any domain where evolution occurs, three processes are crucial and equally important (Staddon, 1993, p. 57): Variation among entities, selection of entities, and retention of the selected changes. The *variation process* offers the raw material out of which better-adapted entities can be selected. The importance of the variation principle is illustrated by the fact that humans do not fly. Humans lack this skill, not because flying would not yield survival benefits to humans but simply because there was no variation in human anatomy and behavior that could have been shaped towards the development of a flying skill (Dawkins, 1989). The *selection process* refers to varying reproduction probabilities of the entities involved. Decreased reproduction rates of the entities result in a decline of the information carriers (e.g., genes) that are

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

responsible for the maladaptive feature. Only the information carriers yielding entities that succeed to reproduce themselves will be maintained. Finally, the *retention process* makes sure that adaptive changes are accumulated throughout generations. Without retention, no complexity could emerge at all.

The Importance of Variation

It is crucial to all kinds of selectionism that there is variation from which to select. That selection mechanisms alone cannot deal with human behavior is an old and valid criticism (Staddon & Simmelhag, 1971). For instance, the successful behavior of Thorndike's (1898) cats could never have been reinforced if the cats had not tried out many alternatives. Likewise, if gene copying were perfect, no evolution would occur at all. Darwinism relies on this variation but assumes that the new variation introduced by errors in gene copying is completely unforeseen and without purpose (Dawkins, 1989).

Although the three processes (variation, selection and retention) have been distinguished in literature (Donahoe & Palmer, 1994), selection and retention seem to have been studied more intensively than has variation. A major concern of behavior analysis (Pierce & Epling, 1995) has been with the effect of reinforcement schedules (i.e., selection) on EBRs. Furthermore, memory (retention) has been the focus of cognitive psychology for many years (e.g., Baddeley, 1992; Kyllonen & Cristal, 1990, see also Donahoe & Palmer, 1994). In comparison, variation processes have been relatively neglected (but see Machado, 1989; Neuringer, 1991; Page & Neuringer, 1985). This is not so surprising because the process of variation and its effects are relatively hidden. There are several reasons for this. First, variation shows its benefits through the result of selection and retention processes only. That is, phenomena that we observe in the present (e.g., *Homo sapiens sapiens*) are outcomes of selection processes. The variation that was required to obtain these phenomena is no longer present. Second, if variation comes to the fore, it is in the form of less successful entities (that is, entities that have not persisted and therefore cannot be used to explain current forms of the entities directly, e.g., *Homo sapiens neanderthalensis*). Therefore, variation tends to be associated with less successful earlier species (or behaviors). Third, in psychology, mechanisms such as rule-governed behavior and imitation seem to circumvent the variation process. Rule-governed behavior refers to behavior that is guided by verbal stimuli or rules (Pierce & Epling, 1995). If the learner has acquired the rule-behavior links in the past and a novel behavioral sequence is explained to her verbally, she starts with a considerable advantage. She does not have to try at random, and therefore it seems as if the role of variation in such instances of behavioral evolution is limited. Nevertheless, we

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

believe that even in these circumstances, variation will still be required to increase fluency of the behavioral sequence. For instance, small adaptations to the (previously acquired) responses might be required to smooth the transition from one behavior to the next. That is, the EBRs change to incorporate past behaviors of the organism as stimuli. Furthermore, the application of verbal rules often requires adaptations during acquisition of behavioral sequences. For instance, although the instruction "put the tape into the tape-player and then push the play-button" might evoke the appropriate behavior in certain circumstances, the rule-behavior link will require some adaptation if it is applied to a new tape-player (for instance because you now have to turn the tape upside down before shutting the deck and then push the play button). In the case of imitation, a similar reasoning applies. In sum, we believe that variation has been studied less extensively than have the other processes involved in evolution (i.e., selection and retention) because it is relatively hidden.

Some researchers have studied the nature of behavioral variability and found that situations may be arranged in such a way that behavioral variability increases (Machado, 1989, 1992, 1993, 1997; Neuringer, 1986, 1992, 1993; Neuringer & Voss, 1993; Page & Neuringer, 1985; Pryor, Haag, O'Reilly, 1969). If behavioral variability is reinforced according to some principle (for instance, the current response should be different from the previous N responses, Page & Neuringer, 1985), behavioral variability increases. Apparently, human (e.g., Neuringer, 1992; Tatham, Wanchisen, & Hineline, 1993) as well as animal subjects (Machado, 1989; Neuringer & Voss, 1993) can learn to vary their behavior. Although this finding is robust, there is no agreement on the source of this variability. According to Neuringer (e.g., 1986, p. 74) the contingencies just described activate an endogenous variability generator. In other words, in this view variability is an operant dimension of behavior. In contrast, Machado (1989, p. 165; 1992, 1993) suggested that probability dependent selection results in increasing behavioral variability. Probability dependent selection refers to reinforcement of the least likely response. If this contingency continues, all responses become equally likely (compare sex ratio in animals reproducing sexually), which is a major feature of randomness. Recent research shows that if the units of selection are larger than the short-term memory capacity (for instance if a unit consists of several elements), probability dependent selection results in random-like behavior (Machado, 1997, experiment 2). Nevertheless, behavioral variability remains lower in such conditions than in conditions where the original procedure is followed (experiment 3). To date, the dispute about the origin of behavioral variability is not resolved. The purpose of the present paper is not to add further evidence that speaks to one of the two possible accounts. Instead, we aim to build on the empirical findings that behavioral

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

variability (or a lack of structure, Machado, 1997, p. 23-24) can increase in certain circumstances. The consequence of increased variability is that unlikely behaviors can become more probable in these circumstances. Because the organisms try many different and improbable solutions, the probability that they come up with the right one in novel situations (that is, situations where old behaviors do not work) increases. Neuringer (1993) indeed found that a mixture of variability dependent reinforcement and reinforcement of an unlikely criterion response increased the occurrence of these unlikely responses. Thus, variation, whatever its source, might speed up the emergence of novel behavior.

The above analysis and Neuringer's finding that variability enhances the acquisition of difficult responses suggests that variation is important in the explanation of complex human behavior whenever the learner does not know the rules or the right way to deal with a novel situation. In the following section, we will analyze the role of variation in three domains of human functioning, specifically, intelligence, humor, and self-regulation, and present specific hypotheses and data. At first sight, it seems difficult to reconcile human inventiveness and creativity, which abound in problem solving, humor, and effective self-regulation with a blind generation process like response mutation, response recombination and mere variability. It might be insightful to note that Darwinism has evoked the same criticisms in biology but that many solutions have been proposed since these initial criticisms (Williams, 1992). The generative component of natural evolution is far from dependent on the mechanism of mutation alone, because mutations are usually fatal to the organism. Rather, mechanisms that shuffle the genetic information (rather than change it) have evolved at various times in evolution (Calvin, 1986). The shuffling is completely blind (or undirected) but not wholly random in the sense that it starts from scratch every time anew: It builds on what exists without foresight on the effects of slight adaptations or novel combinations. The discussion of the survival value of these recombination processes is beyond the scope of this paper (see Calvin, 1986; Ridley, 1993). However, reshuffling creates many new gene combinations, some of which may lead to more adaptive organisms.

Likewise, in a psychological context, recombination of and slight adaptations to old behaviors may result in new behaviors that are more adaptive in the current situation than the old ones. The incentive to try alternatives may come under the control of the environment (Denney & Neuringer, 1998; Neuringer, 1991). For instance, whenever a situation is perceived as a challenge because the most probable response is not up to the task, the organism may have learned to emit a less probable response. These contingencies mimic an extinction procedure (Machado, 1989) and might result in increased behavioral variability if the contingencies persist.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

From the above analysis, it will be clear that other things being equal, a large variety from which to select will be a better initial basis than a small one, because the probability that one trial is near an ideal solution is increased. Increased variation might also refer to the speed with which behavior is generated. Higher variation speed will increase the likelihood that the solution is found, other things being equal. The first aspect of increased variability is not easily studied because the dimensions of variability are hard to define. Individual behaviors differ with respect to many dimensions. To estimate variability, all dimensions should be taken into account (and not only those that are relevant to finding the solution). This is difficult because the researcher risks only taking into account the dimensions that are relevant. For instance, if increasing the pitch of one's voice is an effective strategy to stop a child from doing something forbidden then a parent who says many different things with the same pitch might receive a low variation score. In contrast, a parent trying different pitches might receive a high variation score. In reality however, both attempts should receive similar variation scores. An easier and fairer method is to measure mere generation speed. This precludes biased variation scores. Generation speed is a good estimator of variation, provided that the emitted behaviors differ to some extent. Usually, situations demand varying answers in different trials. For instance, in problem solving, when an attempt does not work, another is required. Likewise, in humor production, a joke will usually lose its power if repeated, provided that the audience remains constant.

Given the benefits of variation (i.e., greater fitness of those who vary more easily), it seems reasonable to assume that natural evolution has resulted in mechanisms that facilitate behavioral variation. Gabora (1998) suggested that the capacity to hold several episodic memories in mind simultaneously facilitates the emergence of a combination of these ideas (provided, of course, that the memories are activated by the environment, which includes the organism's preceding behavior). The lowered threshold for one memory to activate another (Gabora, 1998) seems to be such a hard-wired adaptation that we have alluded to. Although interesting in itself, it is beyond the scope of the present paper to speculate further about phylogenetic adaptations that enhance behavioral variability. Instead we will focus on the benefits of behavioral variability, no matter what are the distal (i.e., phylogenetic) or proximal (i.e., situational contingencies) causes of the process.

In conclusion, variation seems to play an important role in the emergence of difficult behaviors. In the second part of this manuscript, three sets of behaviors that rely on behavioral variation will be discussed from a selectionist perspective. It will be demonstrated that accounts of intelligence, humor, and self-regulation can

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

benefit from taking into account variation principles. For each of these topics, specific hypotheses are derived and data presented.

Intra-individual Behavioral Variation and the Emergence of Complex Behavior

The Role of Variation in Problem Solving and Intelligence

Campbell (1960) already proposed the theory that problem solving is the result of a process of blind variation, selection and retention. The role of selection and retention has been studied intensively. Selection and retention have a prominent role in learning theory (e.g., Thorndike, 1898; Skinner, 1971, 1974; Baum, 1994). In a similar vein, Dennett (1984) defends the idea that the law of effect (which is essentially a law of selection and retention) is a necessary component of any non-question-begging theory of intelligence. Recently, Donahoe and Palmer (1994) have applied the principles of learning theory to a number of "cognitive" tasks, focusing on the aspects of "reminding" and "remembering," two forms of retention (for precise definitions, see the book by Donahoe and Palmer).

Retention is also at the focus of attention in intelligence research. One important factor of individual differences that is often found in this literature is *working memory capacity*, referring, roughly, to the number of elements a person can keep track of while solving a problem (Bachelder & Denny, 1977a, 1977b). Working memory capacity has been repeatedly found to be a clear predictor of individual differences in reasoning tests (e.g., Kotovsky & Simon, 1973; Kyllonen & Cristal, 1990; Carpenter, Just, & Shell, 1990).

The only aspect of this three-process scheme that seems to have been relatively neglected is variation. This was pointed out by Staddon and Simmelhag (1971), who developed *principles of variation* to complement the better known principles of reinforcement of learning theory. Research by Neuringer (1986, 1992) deals explicitly with the role of variation. One typical experiment (Neuringer, 1992) studies whether pigeons can learn to make a choice between repeating a (previously emitted) response and generating a new one. The results are that if novelty is reinforced with a probability π, then the pigeon will match this probability by asymptotically choosing the novel response with the same probability. The idea here is that organisms sometimes can be expected to generate "random" behavior if necessary (see also Pryor, Haag, & O'Reilly, 1969). Another experiment (Neuringer, 1986) shows that people can be taught to generate random sequences (e.g., of coin tosses) if appropriately reinforced.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The previous discussion suggests that in order to exhibit adaptive behavior, a variety of behaviors should be emitted, of which the fittest may be selected (for an overview in the domain of cognitive development, see Siegler, 1989). This leads us to the hypothesis that the mere aspect of speed of generating responses may be a factor of individual differences in (human) problem solving. Consider the following analogy: Two populations of entities in the same or a comparable environment, the first of which evolves faster than the other one. After a fixed period T, the first species is more likely to show adaptive behavior (all other factors assumed constant). Suppose a behavior A is very adaptive in this environment. The faster evolving species will have generated more offspring (tried out more possibilities) and is hence more likely to have discovered A.

This principle can be transferred to psychology: Suppose that there are two persons, one of which generates solution attempts faster than the other one (a series of similar solution attempts is compared to a population in biology). Both persons are given the same problem (comparable to an environment in biology). Under these conditions, we predict that the faster person will have a higher probability of generating a correct solution in a fixed time period T, so this person will have a higher score on an IQ test. So a significant variable of interindividual differences in IQ test scores is, we suspect, generation speed. Raaheim (1974) conducted similar research. This author reported that the "level of activity" of a person (the number of solution attempts on a problem, not counting the correct one) influenced the success of the person on the task. For example, on the "hat rack problem" (Maier & Burke, 1966), Raaheim reports a correlation of .48.

To test this hypothesis, we set up the following study (Verguts, De Boeck, & Maris, in press). A group of $N = 127$ students were given two tests; one was a well-known test of geometric inductive reasoning, the Raven Progressive Matrices Test (Raven, 1962). The other test was devised by us. In this new task, two simple geometrical figures were presented. The task was to complete this row of two figures with a third figure in a logical manner (the "series completion task"). Further, participants were instructed to do this *in as many ways as possible*. Also, for every completion, they had to write down which rule they had used. They were instructed not to take the quality of their rules into account. This task consisted of five items, with a 20-minute time limit. The number of logical completions (over the five items) was taken to be the participant's generation speed (GS) score.

At this point, the following two hypotheses we tested are important. First, we made sure that the GS score was a pure measure of speed of generating alternatives. To be specific, we had to make sure that there were no qualitative differences involved in the completions chosen by different participants. If generating solutions

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is likened to sampling balls (solutions) from an urn, the hypothesis of "no qualitative differences" entails that all persons sample from the same urn. Of course, in complex real-life tasks this assumption is overly simplistic: The individual learning history of each participant will determine which urn will be sampled from (i.e., which solutions are available). Nevertheless, the hypothesis may well hold in our (relatively simple and unfamiliar) series completion task. The conclusion of the testing of this first hypothesis was that there were no qualitative differences between participants on this test (details on how we tested this assumption are provided in Verguts, De Boeck, & Maris, in press). Hence, the GS score reflects a pure "speed of generating solutions" measure. The second hypothesis was that the GS score and the Raven matrices score were correlated. Indeed, we obtained a correlation of $r = .43$ ($p < .001$).

An alternative explanation for this correlation is a motivational one: Highly motivated participants generate many rules on the generation test and solve many items on the Raven test. This explanation was ruled out in the following way. Two sets of Raven items were constructed, one in which finding the correct rule was difficult, one in which finding the rule was not difficult (according to external observers). Both sets had approximately the same standard deviation. Nonetheless, only the Raven scale where rule finding was difficult correlated with the GS score. If motivational differences were responsible for the reported correlation, the generation speed test would correlate with both scales to the same degree.

It may be noted that this correlation is in the range of the highest that are typically found between elementary tasks and complex reasoning tests (e.g., Kyllonen & Cristal, 1990). Hence, the conclusion was that rapid generation of solutions (or creativity) was a factor of individual differences in complex reasoning tests such as the Raven Progressive matrices test. Further studies are planned to analyze this finding in more detail; one study that is planned will investigate whether generation speed can be experimentally manipulated in reasoning tests.

Variation Enhances Humor Production

Modern theories of behavior are often silent about humor, although humor is a substantial aspect of human life. The incentives to explain humor might have been relatively weak because behavioral disorders of interest that are related to humor are rather rare. Nevertheless, the phenomenon itself deserves attention for theoretical reasons. Humor can refer to both humorous behavior and the perception of and the reaction to humor. Although laughing and perceiving funniness are worth investigating as well, we restrict ourselves to humor production.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Humor production is not easily captured by rules. Several theorists have attempted to uncover the essence of humor. The central question is: What is funny and why is it is funny? (e.g., Attardo & Raskin, 1991; Binsted & Ritchie, 1997; Hallett & Derks, 1998; Veatch, 1998). The rules these theoreticians come up with are complex (see Attardo & Raskin, 1991). Although the academic knowledge of the rules has been growing, it is unlikely that good jokers have an explicit knowledge of these rules (i.e., are guided by explicit verbal rules in humor production). This ignorance is similar to a native speaker's (conscious) ignorance of the grammar rules of her mother tongue, although she applies the rules correctly. Nevertheless, a consensus seems to have been reached that humor boils down to a form of *incongruity*, in the sense that two or more elements are combined that usually do not belong together. This idea dates back at least to Skinner (1957). Although this characterization is one step ahead, it can hardly be a good guide for a would-be humorist. First, high levels of incongruity are not considered funny, because they might be absurd or even offending (Veatch, 1998). Likewise, low levels of incongruity may result in lame jokes. Moreover, what is considered optimally incongruent in order to produce good humor importantly depends on the audience involved.

Our assumption that humor production is not guided by verbal rules suggests that humor production might rely heavily on variation processes (see part 1 of this paper). In the first place, each successful joke must be novel (if the audience remains constant). Moreover, jokers have to find a delicate balance between lame jokes (i.e., low levels of incongruity) and absurd or offending jokes (i.e., high levels of incongruity). This skill can only be acquired through intensive exercise. Therefore, we expected that joking frequency (variation) and joking quality be strongly related. Moreover, jokers should be sensitive to social reactions. We distinguish sensitivity to positive feedback (e.g., laughter) and sensitivity to negative feedback (e.g., lack of laughter). From a selectionist point of view, we expected that negative feedback would be required to mould the undifferentiated joking repertoire into a population of funny jokes. This population maintains the delicate balance between congruity and incongruity.

In order to test this theory, we conducted a series of three studies, in which we asked subjects to rate twenty peers on three variables (Dewitte & Verguts, in press):

(1) Does she make a lot of jokes?

(2) Is she socially sensitive?

(3) Is she funny?

Some remarks about the method used are appropriate. For joking, frequency (question 1) approximates variation because the observer is held constant. Indeed,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

we assume that jokes (remarks, exaggerations, and so on) are varied if the same audience (i.e., our rater) is present. Therefore, frequency reflects variation. Concerning the second question, it is important to note that social sensitivity was operationalized as sensitivity to negative cues (no laughter, or reactions such as 'this is an old one' and so on). The results were not conclusive with respect to the social sensitivity variable in study 1 and 2, where we used only sensitivity to negative feedback. Therefore, we differentiated this measure in the third study. We asked the participants to rate their peers on sensitivity to positive cues (appraisal, laughter) as well as on sensitivity to negative cues. The results suggested that both aspects of sensitivity had been taken into account in the first two studies simultaneously (see Dewitte & Verguts, in press, for more details on the method).

Two results are of interest here. First, we found (Dewitte & Verguts, in press) that joke production frequency was strongly related to perceived funniness. The correlations ranged from 0.49 to 0.55 in three studies (with n ranging from 220 to 320). We acknowledge that this finding might also be accounted for by a more traditional explanatory scheme. That is, funny people may be found to produce more jokes *because* they are funny. More specifically, trait 'funniness' has been found to produce higher joking frequency (Ruch, 1996). The following analyses rejected this alternative account. Selectionism expects that people who produce many jokes are not necessarily funny. If they are not sensitive to social reactions to their jokes, they may continue to produce a lot of lame as well as absurd or offending ones. In contrast, people who do not produce many jokes cannot become good jokers. Thus, variation is a necessary condition for joke quality but not a sufficient one. In other words, bad but frequent jokers fit into the selectionist account of joking, whereas good but rare jokers do not. The trait explanation does not predict this difference. As expected by our theory, we found that bad but frequent jokes were far more numerous than good but rare jokers (Dewitte & Verguts, in press). Across the three studies, 43% of the 433 *bad* jokers were evaluated to joke frequently, whereas only 17% of the 327 *good* jokers were found to be joking rarely. This (significant) discrepancy supports our interpretation that variation (i.e., frequency) is a necessary but not sufficient condition for joking quality to occur. Thus, joking frequency seems to come before joking quality.

We will only briefly mention our second main result, because it pertains to selection more than to variation. We found that joking quality was positively related to sensitivity to negative feedback, and *negatively* to sensitivity to positive feedback (Dewitte & Verguts, in press, study 3). Nevertheless, sensitivity to positive cues was positively related with joking frequency. These findings suggest that joking quality results from weeding out the bad jokes from a large population of jokes (sensitivity to negative cues), although sensitivity to positive cues may fuel joking quantity in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

general (irrespective of quality). This pattern of findings supports our selectionist approach. Joking frequency increases with every positive reaction, but joking quality results only if the jokes are adequately selected.

In sum, the data (Dewitte & Verguts, in press) suggest that variation plays an important role in the emergence of being funny. Because good joking is not easily captured by rules, would-be humorists need to vary a lot and be sensitive to social cues. If these requirements are met, the social environment can create good jokers.

A Possible Role of Variation in Self-regulation

Self-regulation refers to the apparent failure of the environment to affect ongoing behavior, although the organism is awake and the relevant stimuli have been shown to affect behavior in the past. For instance, a cat hunting for a bird might fail to perceive her master opening a can of cat meat, because she is extremely focused on the prey. One can say that the cat allocates all the attentional resources it has available towards the hunting behavioral sequence. Likewise, people are often found to do things they do not like, in spite of the availability of more attractive alternatives. They are said to increase motivation for the task at hand (Kuhl & Goschke, 1994). Although we all know the phenomenon of controlling oneself from our everyday experience, it is not clear what the exact nature of motivation might be.

In contrast with humor, self-regulation has enjoyed a lot of attention, although scientific knowledge of the topic is far from perfect (Baumeister, Tice, Muraven & Bratslavski, 1998). The phenomenon has been approached from very different directions, which we will not review here. We will focus on the approach of some behavioral theorists (Ainslie, 1992; Rachlin, 1995) who stress the role of patterning of behavior. Self-control choices become more likely if the behavior is part of a pattern of behavior. For instance, a student facing the choice between watching TV and studying might prefer watching TV at a particular moment. However, studying makes sense because it is part of the overall pattern of behavior leading to eventual academic success. If the student has gone a long way already, continuing becomes more rewarding than it would have been if the studying behavior stood on its own. The increased value of studying might result from (perceiving) previous investments.

Although quite different in their persuasions and in the details of their account of self-regulated behavior, other scholars agree on the fact that self-regulation results from previous behaviors of the self-regulating individual. For instance, some stress the role of goal setting (Gollwitzer & Brandstätter, 1997; Kuhl & Goschke, 1994; Norman & Shallice, 1986). Others discuss the role of intermediate internal

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

reinforcers (Donahoe & Palmer, 1994; Pierce & Epling, 1995). Still others suggest that self-monitoring (i.e., perception of their own previous behaviors) plays an important role in self-regulation (Carver & Scheier, 1981; Lord & Levy, 1994). We will not focus on the differences between these approaches. Instead, we will rely on the agreement of these scholars that the organism's behaviors that occur (immediately) before the decision to persist are important (be they goal representations, self-perceptions, or internal reinforcers).

Several theorists (Ainslie, 1992; Carver & Scheier, 1981; Rachlin, 1995; Vallacher & Wegner, 1987) suggested that a broad perspective on an action enhances its continuity. That is, people who perceive patterns of behavior rather than a single behavior are more likely to persist at the current behavior. One of the mechanisms that is thought to be responsible is that behavior that occurred a time ago as a part of the current pattern becomes a stimulus itself for the following behavior. It becomes a stimulus through the perceived pattern. That is, the individual stimulus may be out of sight, but jointly, previous stimuli result in a perceived pattern. When the pattern is not perceived, no previous behavior but the last influences the following behavior. When the pattern is perceived, behavior that occurred some time ago can control subsequent behavior (compare with environmental chaining, Donahoe & Palmer, 1994, p. 100).

How can the perception of a pattern of behavior be facilitated? We will focus on the role of variation. We believe that faster variation in behavior will enhance the perception of complex patterns of behaviors. If the second most recent behavior is still close enough when the most recent behavior is emitted, the two most recent behaviors jointly influence the next behavior. The individual will then be more likely to describe her behavior in more encompassing phrases. If behaviors appear at a slow rate, the influence of the second most recent behavior will have faded before the most recent behavior is emitted.

We tested this hypothesis by means of a series of free continuous association tasks (Dewitte & Lens, 1999a). In a continuous association task, a stimulus word is presented and the individual is allowed to associate with this word (but not with self-generated words) as long as she wants to (Cramer, 1968). If she decides that she has generated enough words, she goes on to the next page, where a new stimulus word is presented. Variation speed was manipulated (between subjects) by affecting difficulty of stimulus words (negative words trigger fewer other words than do positive words [Cramer, 1968]). After several trials, the participants were asked "What are you doing?" (For more details on the method, see Dewitte & Lens, 1999a; Vallacher & Wegner, 1985). The answer reflected the level of generalization with which the participants made sense of their previous behavior. Three categories were distinguished. Action descriptions were classified as narrow (i.e., focused on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

only one specific behavior; e.g., "I'm thinking about the meaning of the word "), broad (i.e., focused on the entire task, e.g., "I'm associating"), or very broad (i.e., focused on the context of the task, e.g., "I'm helping this researcher"). The very broad descriptions will not be discussed here, because they are not directly guided by the task behaviors; see Dewitte & Lens (1999a). After writing down the action descriptions, the participants continued associating. The variation speed manipulation was reversed. That is, participants who had received difficult words in the first part now received easy words and vice versa. The time they kept trying in the four final trials was taken as a measure of persistence.

Two results are of interest here. First, we found clear evidence that high variation speed facilitated broad action descriptions and that low variation speed resulted in narrow descriptions. This result appeared not only when the effect of manipulated variation speed was evaluated, but also when variation speed was used as an individual variable. Individuals with greater variation speed were more likely to give broad action descriptions than individuals with smaller variation speed.

Second, broad action descriptions resulted in better persistence than narrow action descriptions, even if ability was controlled for. This relation was only obtained for participants who did not like the association task. For those who liked the task, that is, those who did not have to 'self-regulate' to persist, this relation was not found. This interaction between desirability and the breadth of action descriptions supported our conclusion that breadth of action descriptions is involved in self-regulation.

The conclusion of this experiment is that behavioral variation speed facilitates perception of one's own behavior that encompasses not only the most recent behavior, but also older behaviors. In turn, and irrespective of variation speed, this perception affects persistence later on. In experiments where we used different methods (writing tasks, word anagrams; Dewitte & Lens, 1999b), we showed that the relation between broad action descriptions and persistence was reliable. People who were confronted with two competing tasks spent more time and performed better on the less attractive task when they described their action in broader terms. For the more attractive task, this relation was not found. Neither was it when the attractiveness of both tasks were comparable. Dewitte and Lens (1999c) showed that the relation between ability (which was measured on a different task and which is believed to enhance variation speed) and eventual persistence on difficult word anagrams was mediated by the breadth of the action description.

In conclusion, we gathered some evidence that higher variation speed enhanced encompassing perceptions of the behavior. In turn, this encompassing perception served as a persistence-enhancing stimulus itself. It is also possible that the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

perception serves as a secondary (internal) reinforcer. The action perspective might be one instance of the internal secondary reinforcers that Donahoe and Palmer alluded to (1994). Behaviors that are not liked for their own sake are reinforced by the emergence of a broad action perspective. As a result, these behaviors are repeated. We acknowledge that there might be an alternative explanation. It might be the case that mere generation speed and not variation in itself was responsible for the effects. For instance, partial reinforcement also leads to more persistence than does continuous reinforcement. This effect might well be mediated by the perceived pattern of behavior. That is, an organism that is partially reinforced learns that emitting a *number* of behaviors results in reinforcement, whereas an organism that is reinforced after every response learns that only one behavior suffices to get the reward. It appears that the breadth of an action perspective might also be facilitated by mere speed and not variation (that is, by repetition of the same response). However, in real life, persistence will often involve variation of behavior (for instance in problem solving, see above). Therefore, we feel confident that the skill to vary might be an important variable in increasing generation speed.

Discussion and Conclusions

The analogy between psychology and biology offers a perspective for a large number of psychological phenomena. This is the case because behavior is varied, selected and retained, and therefore evolves throughout life in conceptually similar ways as species do in their natural environments. Our paper focused on the role of variation in the emergence of some types of complex behaviors because in our opinion, it had been relatively neglected in comparison with selection and retention processes. First, we outlined some reasons for stressing the role of variation. We suggested that many complex behaviors are not easily captured by rules. In the second section, we further investigated the possible role of variation in the emergence of problem solving, humor production, and self-regulation.

With respect to problem solving, evidence was provided that generation speed is an important variable of individual differences in intelligence scores. Even if the rules that different individuals dispose of are highly similar, individuals with high generation speeds are more likely to come up with a good solution than are those with low speeds. This finding suggests that even if individuals have similar knowledge bases, individuals who generate responses quickly will deal with problems more adaptively than slow individuals. In our opinion, the consideration of different learning histories will only exacerbate this difference. This is because faster generators will probably also learn faster in general. Neuringer (1993) provided experimental evidence that (experimentally induced) variation enhanced the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

acquisition of difficult responses. It seems reasonable that any factor that enhances variation (besides reinforcement schedules) will have similar effects. In the long term, this will lead to a richer repertoire for individuals who generate faster.

We also discussed data that suggested that the acquisition of joking skill requires sustained variation. Variation was not measured as rigorously as it was in the experiments on problem solving. Nevertheless, it seems reasonable to assume that joking frequency and variation are strongly interrelated, particularly because the observers were held constant. The frequency variable was found to be the best predictor of joking quality. Alternative explanations were ruled out.

Finally, the data on self-regulation showed that variation might be an important variable enhancing the perception of a chain or pattern of behaviors. This behavioral pattern itself, in the role of a new stimulus, might facilitate sustained efforts. The data provided preliminary evidence for this hypothesis. We suggested, tentatively, that the pattern might also play the role of a secondary reinforcer.

In conclusion, the theoretical analyses and the series of studies presented suggest that variation may play an indispensable role in the emergence of several types of complex behavior. We suggest that future research focus on other ways to measure variation and on its impact.

REFERENCES

Ainslie, G. (1992). *Picoeconomics: The strategic interaction of successive motivational states within the person.* Cambridge, UK: Cambridge University Press.

Attardo, S., & Raskin, V. (1991). Script theory revis(it)ed: Joke similarity and joke representation model. *Humor: International Journal of Humor Research 4*, 293-347.

Bachelder, B. L., & Denny, M. R. (1977a). A theory of intelligence: I. Span and the complexity of stimulus control. *Intelligence, 1*, 127-150.

Bachelder, B. L., & Denny, M. R. (1977b). A theory of intelligence: II. The role of span in a variety of intellectual tasks. *Intelligence, 1*, 237-256.

Baddeley, A. (1992). Is working memory working? *Quarterly Journal of Experimental Psychology, 44A*, 1-31.

Bailey, C. H. & Kandel, E. (1995). Molecular and structural mechanisms underlying long-term memory. In M. S. Gazzaniga et al. (Eds.), *The cognitive neurosciences*, pp.19-36.

Baum, W. M. (1994). *Understanding behaviorism. Science, behavior, and culture.* New York: Harper Collins College Publishers.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*, 1252-1265.

Binsted, K. & Ritchie, G. (1997). Computational rules for generating punning riddles. *Humor: International Journal of Humor Research 10*, 25-76.

Buss, D. M., Haselton, M. G., Shackelford, T. K., Bleske, A. L., & Wakefield, J. C. (1998). Adaptations, exaptations, and sprandrels. *American Psychologist, 53*, 533-548.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Calvin, W. H. C. (1986). *The river that flows uphill: A voyage through the evolution of the brain.* Washington, DC: Washington University Press.

Campbell, D. T. (1960). Blind variation and selective retention in creative thought as in other knowledge processes. *Psychological Review, 67,* 380-400.

Carpenter, P. A., Just, M. A., & Shell, P. (1990). What one intelligence test measures: A theoretical account of processing in the Raven Progressive Matrices Test. *Psychological Review, 97,* 404-431.

Carver, C. S. & Scheier, M. F. (1981). *Attention and self-regulation: A control-theoretical approach to human behavior.* Berlin, Germany: Springer-Verlag.

Cramer, P. (1968). *Word Association.* New York: Academic Press.

Cziko, G. (1995). *Without miracles. Universal selection theory and the second Darwinian revolution.* Cambridge, MA: MIT Press.

Dawkins, R. (1989). *The selfish gene* (new edition). Oxford, UK: Oxford University Press.

Dennett, D. C. (1984). *Brainstorms. Philosophical essays on mind and psychology.* New York: Montgomery Bradford Books.

Dennett, D. C. (1995). *Darwin's dangerous idea: The evolution and the meaning of life.* London, UK: Penguin.

Denney, J. & Neuringer, A. (1998). Behavioral variability is controlled by discriminative stimuli. *Animal Learning and Behavior, 26,* 154-162.

Dewitte, S., & Lens, W. (1999a). Determinants of the action identification level and its influence on self-control. *Psychologica Belgica, 33,* 1-14.

Dewitte, S., & Lens, W. (1999b). Persistence on unattractive tasks without external pressure: The role of the action identification level. *Psychological reports, Centrum for motivation and time perspective,* (No. 82). *University of Leuven, Belgium.* Manuscript submitted for publication.

Dewitte, S., & Lens, W. (1999c). Overcoming the inclination to quit a boring task: The role of the action identification level. *Psychological reports, Centrum for motivation and time perspective,* (No. 85). *University of Leuven, Belgium.* Manuscript submitted for publication.

Dewitte, S., & Verguts, T. (in press). Being funny: A selectionist theory of being funny. *Humor: An International Journal of Humor Research.*

Donahoe, J. W., & Palmer, D. C. (1994). *Learning and complex behavior.* Boston, MA, US: Allyn and Bacon.

Edelman, G. M. (1992). *Bright air, brilliant fire: On the matter of the mind.* New York: Basic Books.

Gabora, L. (1998). The origin of culture. *Psycholoquy, 9,* 67. *(http://www.cogsci.soton.ac.uk/cgi/psyc/newpsy?9.67)*

Gollwitzer, P. M., & Brandstatter, V. (1997). Intentions and effective goal pursuit. *Journal of Personality and Social Psychology, 73,* 186-199.

Hallett, R. A. & Derks P. (1998) Humor theory and Rabelais. *Humor: International Journal of Humor Research 11,* 135-160.

Hendriks-Jansen, H. (1996). *Catching ourselves in the act: Situated activity, interactive emergence, evolution, and human thought.* Cambridge, MA, US: The MIT Press.

Kotovsky, K., & Simon, H. A. (1973). Empirical tests of a theory of human acquisition of concepts for sequential patterns. *Cognitive Psychology, 4,* 399-424.

Kuhl, J. & Goschke, T. (1994). A theory of action control: Mental subsystems, modes of control, and volitional conflict-resolution strategies. In J. Kuhl & J. Beckmann, (Eds.), *Volition and personality. Action Versus State orientation,* (pp. 93-126). Seattle, WA: Hogrefe & Huber Publishers.

Kyllonen, P., & Cristal, R. (1990). Reasoning ability is (little more than) working memory capacity. *Intelligence, 14,* 389-434.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Lord, R.G. & Levy, P.E. (1994). Moving from cognition to action: A control theory perspective. *Applied Psychology: An International Review, 43*, 335-398.

Machado, A. (1989). Operant conditioning of behavioral variability using a percentile reinforcement schedule. *Journal of The Experimental Analysis of Behavior, 52*, 155-166.

Machado, A. (1992). Behavioral variability and frequency-dependent selection. *Journal of The Experimental Analysis of Behavior, 58*, 241-263.

Machado, A. (1993). Learning variable and stereotypical sequences of responses. Some data and a new model. *Behavioral processes, 30*, 103-130.

Machado, A. (1997). Increasing the variability of response sequence in pigeons by adjusting the frequency of switching between two keys. *Journal of The Experimental Analysis of Behavior, 68*, 1-25.

Maier, N. R., & Burke, R. J. (1966). Test of the concept of "availability of functions" in problem solving. *Psychological Reports, 19* 119-125.

Neuringer, A. (1986). Can people behave "randomly?": The role of feedback. *Journal of Experimental Psychology; General, 115*, 62-75.

Neuringer, A. (1991). Operant variability and repetition as functions of interresponse time. Time. *Journal of Experimental Psychology: Animal Behavior Processes, 17*, 3-12.

Neuringer, A. (1992). Choosing to vary and repeat. *Psychological Science, 3*, 246-250.

Neuringer, A. (1993). Reinforced variation and selection. *Animal Learning and Behavior, 21*, 83-91.

Neuringer, A. & Voss, C. (1993). Approximating chaotic behavior. *Psychological Science, 4*, 113-119.

Norman, D. A. & Shallice, T. (1986). Attention to action. Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz & D. Shapiro (Eds.), *Consciousness and self-regulation Vol. 4*. New York: Plenum Press.

Page, S., & Neuringer, A. (1985). Variability is an operant. *Journal of Experimental Psychology: Animal Behavior Processes, 11*, 429-452.

Piatelli-Palmarini, M. (1989). Evolution, selection and cognition: From "learning" to parameter setting in biology and in the study of language. *Cognition, 31*, 1-44.

Pierce, W. D., & Epling, W. F. (1995). *Behavior analysis and learning*. New Jersey, NJ: Prentice Hall.

Pryor, K. W., Haag, R., & O'Reilly, J. (1969). The creative porpoise: Training for novel behavior. *Journal of the Experimental Analysis of Behavior, 12*, 97-103.

Raaheim, K. (1974). Problem solving and intelligence. Bergen, Norway: Universitetsforlaget.

Rachlin, H. (1995). Self-control: Beyond commitment. *Behavioral and Brain Sciences, 18*, 109-159.

Raven, J. C. (1962). *Advanced Progressive Matrices, set II*. London, UK: H. K. Lewis.

Ridley, M. (1993). *The Red Queen: Sex and the Evolution of Human Language*. London: Penguin Books.

Ruch, W. (1996). Measurement approaches to the sense of humor: Introduction and overview. *Humor: International Journal of Humor Research 9*, 239-250

Siegler, R. S. (1989). Mechanisms of Cognitive Development. *Annual Review of Psychology, 40*, 353-379.

Skinner, B. F. (1957). *Verbal behavior*. New Jersey, NJ: Prentice Hall.

Skinner, B. F. (1971). *Beyond freedom and dignity*. New York: Knopf.

Skinner, B. F. (1974). *About behaviorism*. New York: Knopf.

Skinner, B. F. (1981). Selection by consequences. *Science, 213*, 501-505.

Staddon, J. E. R. (1993). *Behaviorism. Mind, mechanism and society*. London: Duckworth.

Staddon, J. E. R., & Simmelhag, V.L. (1971). The "superstition" experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review, 78*, 3-43.

Tatham, T. A., Wanchisen, B. A., & Hineline, P. N. (1993). Effects of fixed and variable ratios on human behavioral variability. *Journal of the Experimental Analysis of Behavior, 59*, 349-359.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Thorndike, E. L. (1898). Animal Intelligence: An experimental study of the associative processes in animals. *The Psychological Review Monograph Supplement*, 2.

Vallacher, R. R., & Wegner, D. M. (1985). *A theory of Action Identification*. New Jersey, NJ: Erlbaum Hillsdale.

Vallacher, R. R., & Wegner, D. M. (1987). What do people think they're doing? Action identification and human behavior. *Psychological Review, 94*, 3-15.

Veatch, T. C. (1998). A theory of humor. *Humor: International Journal of Humor Research 11*, 161-215.

Verguts, T., De Boeck, P., & Maris, E. (in press). Generation speed in Raven's Progressive Matrices Test. *Intelligence.*

Williams, G. C. (1992). *Natural selection: Domains, levels, and challenges.* New York: Oxford University Press.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.