Variability in Life Can Facilitate Learning to Live Together

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In this paper I propose that happiness can be achieved by being variable in everything that we do. Being variable results in being adaptable in difficult situations such as dealing with other people that are different to you. By promoting variability in our lives, we can become more contented as we can overcome many obstacles. Striving to be variable in every aspect of our lives can promote a happier and healthier life that can translate to improved tolerance and adaptability in our social interactions. Variability in our lives can thus facilitate learning to live together.

Learning to live together (LLT) can be defined as a process of acquiring knowledge about others and their way of living, in order to co-exist in harmony. United Nations has even developed "courses" to promote LLT since there is a belief that such a process will result in fewer conflicts, an increased tolerance with respect to differences among cultures, and the promotion of peace and world happiness. Therefore, in these courses students are exposed to other cultures, religions and ways of living in order to reduce ignorance.

My proposition to achieve LLT and its associated goals is different. I believe that if we are happier ourselves, we can tolerate others and their differences and can co-exist more effectively. Consider the following. If you are in a very happy state, someone can insult you or may even hit you, but you may actually laugh or dismiss it in your overall state of happiness. However when you are unhappy, you can be irritated much easier and your tolerance level is pretty low regarding anything that you don't like or want.

Therefore, I propose that if we want to promote LLT, we may be able to achieve significant results through the promotion of personal happiness. This creates a critical question: how can I achieve personal happiness? This is a question that has been asked by almost everybody through the centuries and has created volumes of

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books and manuscripts. However my approach is unique and quite mechanistic. I propose that happiness could be achieved by being variable in everything that we do. Being variable results in being adaptable in difficult situations, including when dealing with people that are different to us.

To allow for a better understanding of this proposition, as an example I will use movement, which is the area within which I conduct my research. When we perform the same task multiple times, we can easily observe that we never execute it the exact same way. This is obvious even with elite performers such as athletes and musicians. When it comes down to simple everyday walking every one of us is an elite performer, but as we observe our steps behind us on the sand we can clearly see that they are never identical. These natural fluctuations in motor performance define the presence of variability which is ubiquitous in all biological systems. In other words, variability is a fact of life (Harrison and Stergiou 2015; Stergiou and Decker 2011).

For years variability was considered as an indicator of undesirable noise in the control system (Newell and Corcos 1993; Schmidt and Lee 2005). This position was likely due to the common use of linear statistical measures (e.g. standard deviation) to study variability (Stergiou et al. 2006). Such measures contain no information about how the motor system responds to change over time. Practically, the linear measures are measures of centrality and thus provide a description of the amount or magnitude of the variability around that central point. This is accomplished by quantifying the magnitude of variation in a set of values independent of their order in the distribution. From this perspective, clinicians and scientists believe that the mean is the "gold standard" of healthy behavior. Any deviation from this gold standard is error, or undesirable behavior, or the result of instability. However, recent literature from several disciplines including brain function and disease dynamics have shown that many apparently "noisy" phenomena are the result of nonlinear interactions and have deterministic origins (Amato 1992; Buchman et al.2001; Cavanaugh et al. 2010; Garfinkel et al. 1992; Goldstein et al. 1998; Orsucci 2006; Slutzky et al. 2001; Toweill and Goldstein 1998; Wagner et al. 1996). In movement, the study of variability was massively enhanced by instrumentation that has allowed scientists to put movement literally under the microscope. Cameras that can capture movement in hundreds of pictures per second (our eye can only see 12–15 pictures per second) and computers that can store and process with amazing speeds such an abundance of data, has allowed us to observe movement with detail that parallels what Koch and Fleming were able to see when they had blood under their microscopes.

As a result, it was found that stride-to-stride variations in healthy walking exhibit nonlinear and fractal-like fluctuations extending over hundreds of steps. The classic definition of a fractal, first described by Mandelbrot (Mandelbrot 1977), is a geometric object with "self-similarity" over multiple measurement scales (Stergiou 2016). The outputs of the locomotor system measured over time exhibit such fractal properties (Delignieres and Torre 2009), demonstrating power-law scaling such that the smaller the frequency of oscillation (f) of these signals, the larger their amplitude (amplitude squared is power) (Harrison and Stergiou 2015; Stergiou 2016). This power-law relation can be expressed as 1/f, and is referred to as pink noise, where oscillations appear self-similar when observed over seconds, minutes, hours, or days. In terms of a distribution, this means that when we naturally walk, the variations of our strides are not normally distributed but instead we have a few big strides, many medium size strides, and a huge number of small size strides.

Importantly, such nonlinear and fractal-like 1/f distributions exist everywhere around us (e.g. in trees, lightning, cloud formation) and inside us (e.g. in our airways, intestine folds, blood vessels). Furthermore, we also have an affinity for such patterns. A work of art is pleasing if is neither too regular/predictable, nor packs too many surprises. Such patterns are ubiquitous in human performance that we observe in music, art, elementary motor tasks, cognitive tasks, etc.

These observations have allowed the development of new theoretical frameworks to study movement variability. Thus, it has been proposed that the natural fluctuations that are present in normal motor tasks (e.g. stride-to-stride fluctuations in normal walking) are characterized by an appropriate or optimal state of variability (Harrison and Stergiou 2015; Stergiou et al. 2006; Stergiou and Decker 2011). Optimal variability is associated with nonlinear and fractal-like 1/f distributions. This physiologic complexity enables an organism to function and adapt to the demands of everyday life (Harrison and Stergiou 2015; Stergiou et al. 2006; Stergiou and Decker 2011). This physiological complexity is recognized as an inherent attribute of healthy biological systems, whereas the loss of complexity, for example with aging and disease, is thought to reduce the adaptive capabilities of the individual. A loss of complexity results in an overly constrained, periodic and rigid system, or an overly random, noisy, incoherent system.

There are compelling findings in both animal and human studies that suggest that the complexity of locomotor patterns provide a rich source of information that could be relevant to the diagnosis and management of a variety of diseases that affect an aging population. Our previous research has shown that highly active older adults exhibit more complex patterns of locomotor activity than less active older adults, despite the absence of differences between these groups in standard measures of variability of their step counts (Cavanaugh et al. 2010). Hu and colleagues have recently shown that older adults and dementia patients have disrupted fractal activity patterns (Hu et al. 2009) and that the degree of disruption is positively related to the burden of amyloid plaques—a marker of Alzheimer's disease severity (Hu et al. 2013). They also found that fractal scaling in activity fluctuations is unrelated to the average level of activity as assessed within and between subjects (Hu et al. 2004). A study of primates suggests that a loss of complexity in locomotor behaviour that is associated with illness and aging, reduces the efficiency with which an animal is able to cope with heterogeneity in its natural environment (Macintosh et al. 2011). Japanese quail became less periodic and more complex in their locomotor behaviour when they were stimulated to explore, without there being commensurate changes in the percentage of total time spent walking, or in the average duration of the walking events (Kembro et al. 2009). Additionally, fractal scaling has been observed in the locomotor activity of young, healthy small mammals, a feature that is less evident in aged animals (Anteneodo and Chialvo 2009).

In summary, an optimal level of variability enables us to interact adaptively and safely to a continuously changing environment, where often our movements must be adjusted in a matter of milliseconds. A large body of research exists that demonstrates natural variability in healthy gait (along with variability in other, healthy biological signals e.g. heart rate), and a loss of this variability in ageing and injury, as well as in a variety of neurodegenerative and physiological disorders. In 1944, Erwin Schrodinger said something similar in his book "What is Life". Specifically he stated that "Life is an aperiodic crystal, it is not random, but also is not periodic, it is something in between." From my perspective variability may be the spice of life.

Now let us return to LLT and my proposition. As a reminder, I have proposed that happiness could be achieved by being variable in everything that we do. Being variable results in being adaptable in difficult situations such as dealing with other people that are different to you. By promoting variability in our lives, we can become much happier as we can overcome many obstacles. This approach also keeps as healthier which further enhances happiness.

Recommendations

How can we promote variability in our lives? In many different ways. For example, when we drive to work in the morning we can purposely select different pathways. At the same time we can also use fractal-like 1/f distributions. For example, when we eat we can be variable in terms of the types of foods and their calories. We can eat a few pieces of food that have many calories (i.e. chocolate), more pieces of food that have less calories (i.e. meat), and a huge number of food that have a very small amount of calories (i.e. vegetables). Isn't actually this type of a distribution what is recommended by almost every diet that promotes health?

In conclusion, striving to be variable in every aspect of our lives can promote a much happier and healthier life that can easily translate in improved tolerance and adaptability in our social interactions. Variability in our lives can thus facilitate learning to live together.

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