Which one is better: Assessment and Locomotion imitation strategies in Changing Environments

Cunying Chen* and Hua Zhang†

1 Department of IT Development & Management, Hua Qiao University, Quanzhou, Fujian Province, 362021, China
2 Business School, Hua Qiao University, Quanzhou, Fujian Province, 362021, China
*Corresponding author’s e-mail: chencunying@hqu.edu.cn

Abstract. Imitation is ubiquitous, yet what self-regulation orientations’ role played in imitation strategies is poorly understood, which is particularly challenging in dynamic and uncertain environments. According to regulatory mode theory, we model two imitation strategies: assessment and locomotion. Assessment pays more attention on comparasion among different alternatives, they repeatedly measure, evaluate, and compare desired means and try to find out the ‘best’ one. Contrariwise locomotion refers to ‘keep moving’, once choosing one alternative, they change some choices and learn from the resulting performance feedback. Using a computational model, we explore the performance implications of dynamic environments for these two imitation strategies. Consequently, when environment is stable, assessment is more effective in maintaining the lead, whereas locomotion prevails as environmental changes become more frequent and substantial. We contribute to the literatures on strategy, imitation, and NK studies.

1. Introduction
The strategy and organization literature has paid substantial attention to imitation not only because imitation is ubiquitous, but also because imitation is a frequently-used approach to learning and central way to get competitive advantage [1]. However, what has yet to be considered is the possibility that self-regulation orientations play a role in how their imitation. Yet the efficiency of imitation strategies is poorly understood, which is particularly challenging in dynamic and uncertain environments.

Regulatory mode theory posits that people have two key self-regulation orientations towards movement: assessment and locomotion [2]. When people adopt assessment imitation strategy, they make comparisons among alternatives. While when people use locomotion imitation strategy, they prefer to change some choices and learn from the resulting performance feedback once they pick up an alternative. Moreover, although several studies have used NK model to examine the imitation outcomes, they have paid less attention to dynamic and uncertain environments [3]. Such environments are often characterized by uncertainty arising from sudden environmental shifts, that is, landscape changes every f period with w magnitude. In this paper, we build on this burgeoning stream of research to examine the efficacy of assessment and locomotion imitation strategies in changing environments.

The main contributions of this paper are summarized as follows:
• To the best of our knowledge, ours is the first study to simulate locomotion and assessment orientations in a computational model to explore the non-linear relationship between imitation strategy and dynamic environment, extending the traditional NK model.
• We extend the current research on regulatory mode theory in the context of dynamic and uncertain environment. Most studies on regulatory mode are rooted in psychology. We introduce this theory to Artificial Intelligence research and highlight its value in predicting the performance implication of agents’ problems solving strategy.

This paper is organized as follows. First, we review the literature and introduce the related work which provide the foundation for our work. Second, we develop a computational model of imitation through which we examine the performance implication for the two imitation strategies. Next, we implement the extended NK model and analyze the final results. At last, we conclude by briefly highlighting key theoretical insights resulting from our analysis and discussing limitations of our research.

2. Related work

2.1. NK Performance Landscape and environmental changes
While in the traditional NK model the environment is typically assumed to be stable, recently some scholars considered the environmental change which constitutes a break with the past. Csaszar and Siggelkow [4] altered the landscape at regular intervals by changing the payoffs of each solution to introduce the changing performance feedback. Since Csazar’s work, scholars construct the changing environment model with modifying the payoffs. Sharapov [5] created another landscape using the same N and K, and introduced the weight w representing the magnitude of environmental changes, and the frequency f representing the length of changing intervals. With the changing environment model the author investigated how different leader-rival imitation strategies in a changing environment affect the leader’s performance over time. Similarly Dirk M [6] introduced a coefficient which can take any value between -1 and +1 to reflect the correlation between the payoffs pre- and post-environmental change. Particularly if the correlation is one, the environment is stable, and if the correlation is positive, payoffs which are bad in the past become good through the change (and vice versa). Changing environment model has both important practice and theoretical meanings, by exploring the role of environmental changing for different searching strategies, we relax the assumption of static environments in prior research on exploring the performance implication of alternative strategies.

2.2. Regulatory Mode Theory
Regulatory mode theory suggests that locomotion and assessment orientations are universal tendencies. Assessment pays more attention on comparation among different alternatives, they repeatedly measure, evaluate, and compare desired means and try to find out the ‘best’ one. Contrariwise locomotion refers to ‘keep moving’, they pursue changes from one state to a desired other state even final state leads to a worse situation[7]. Prior studies also indicated that either can be used in research and popular in practice. In fact, locomotion and assessment are quite different in the nature and consequences and they are independent [8]. That is, individuals who are both high in locomotion and low in assessment, vice versa, while there are also individuals who are both high in locomotion and assessment or both low. We should note that locomotion and assessment would compete for an individual’s resources. Although there may be many possible combinations of locomotion and assessment, we shall consider each individually. Even an individual who is both high in locomotion and assessment, however, in a given situation, he or she will emphasize one or the other mode. Specific activities would be token by any individual at any time point. This paper is concerned with the performance implication when individuals emphasize locomotion or assessment in their goal pursuits.
2.3. Imitation Strategy and Regulatory Mode

To solve a problem, regardless of its complexity and uncertainty, a searching strategy must be identified. Two alternative strategies are typically modeled in prior literature: experimentation strategy and imitation strategy [9]. Local search can be seen as a typical experiential strategy that involves changing only one choice at a time and decide whether to accept the new solution or deny it from the performance feedback. Rather than exploring the landscape itself, imitation strategy relies on imitating the other agents’ solutions. Imitation strategy is a substitute for experimentation strategy in the sense that it allows for simultaneously changing several choices. Gavetti and Levinthal [10] introduced cognitive representations in search strategy research. Cognitive representations are modeled as a part of the real landscape. Although it is rough and partial it can improve the effectiveness of search. In this case, experimentation strategy can be seen as a looking-forward strategy depending on the cognitive map while imitation strategy belongs to looking-backward strategy depending on the performance feedback.

This study benefits from the above research. Self-regulation orientations capture the human nature and there is little we know about the performance implication of imitation strategies based on the two orientations in a changing environment. Aiming at exploring which imitation strategies have a better performance in a changing environment, the locomotion and assessment are introduced and the related strategies are defined in detail.

In this paper, the two parameters: the frequency and magnitude are defined to measure the changing environment. Our computational model extends the original NK model and provides a more comprehensive and in-depth understanding of problem-solving process.

3. Model

To investigate how different imitation strategies in a changing environment affect the performance over time, we use an adapted version of an NK simulation model. In our model, agents use locomotion and assessment imitation heuristics to traverse a fitness landscape. According to NK model, N represents the number of binary choices, each of which is interdependent with K other choices (drawn randomly in our model).

We use a moderately rugged landscape with $N = 10$ and $K = 4$ to reflect important interdependencies between choices, which are present in many previous literature settings. To introduce environmental changes into our simulation, we alter two parameters $w$ and $f$. The weight $w$ reflects the magnitude of environmental changes, while the frequency $f$ of changes corresponds to the length of intervals between periods in which the landscape is altered.

Agents conduct two different imitation strategies: locomotion and assessment. According to regulatory mode theory, assessment takes the superior configuration as a reference point in a distant search process while locomotion tries to change some choices at a time and learning from the resulting performance feedback.

4. Simulation Results

4.1. Implementation

We consider two agents randomly seeded on the landscape at the start of each run of the simulation. The performance is updated in every simulation period. Our simulation last for 100 periods which make sure the two imitation strategies get final performance level, and we perform 1000 runs of each simulation. Alongside the two imitation strategies, we vary the frequency ($f = 10$ to 100, corresponding to the landscape changing every $f$ periods) and magnitude ($w = 0.1$ to 0.9, corresponding to the weight given to the newly-generated performance landscape, with $1 - w$ being the weight assigned to the previous one) of environmental changes. Note that high levels of environmental variations are associated with low values of $f$ and high values of $w$. The detail parameters are following.
Table 1. Summary of Model Parameters.

| Parameter | Definition |
|-----------|------------|
| Environment | N: the number of choices  
| | K: the number of other choices which influence each N  
| | f: the length of intervals between periods in which the landscape is altered  
| | w: the magnitude of environmental changes |
| Locomotion | Keeping compare all the superior alternatives |
| Assessment | Once choose one alternative try to change some choice to learn the feedback |

4.2. Analysis

We use this analytical structure of NK model and assessment and locomotion imitation strategies to engage in two sets of analyses. The first examines the differences in performance of the assessment and locomotion imitation strategies under stable and dynamic environment, while the second set extends this comparison to explore the final performance level considering both magnitude and frequency of environmental changes.

4.2.1. The differences in performance of the assessment and locomotion imitation strategies under stable and dynamic environment. Figure 1 shows, in stable environments, assessment outperforms locomotion all the time. By contrast, in dynamic environments, assessment imitation strategy can not regain the lead all the time. Indeed, as figure 2 shows, assessment outperforms locomotion in the short run while locomotion get a much higher performance level holding the frequency and magnitude of changes fixed (f=10, w=0.1).

4.2.2. Final performance gaps under different magnitude and frequency of environmental changes. We take the performance gaps between the locomotion and assessment in final time, this measure of performance captures the fluctuations of these relative performances and is a function of environmental changes. Figure 3 shows, an increase in the magnitude of environmental changes appears to increase the performance level of locomotion imitation strategy relative to assessment imitation, with this effect being most pronounced when magnitude increases from moderate to high (f = 50 to 90). The results are more complexity under different frequency of changes. As figure 4 shows, low and moderate frequency leads to a large performance gap, when magnitude increases from low to
moderate (w=0.1 to 0.5) low frequency (f=10) get a better performance gap, while when magnitude increases from moderate to high (w=0.5 to 0.9) moderate frequency (f=50) outperforms.

The above findings can be explained by considering the trade-off between exploration and exploitation. The most pronounced difference between locomotion and assessment is that locomotion can be seen as a series of experiments due to their strong willingness to keep moving. When environment is stable rugged-landscape models offer results that locomotion is local and fails to consider the superior alternatives, it will likely lead to a low local peak. That is the reason why assessment outperforms under stable environments. When environments change, assessment is no more a better substitute for experimentation. In this case it is not a good ideal for decision making without considering the experimental learning process. Dynamic and complex changing environment make it difficult to only rely on imitation. Assessment imitating too much precludes the potential for subsequent improvements through local search. Our simulation results echo March’s (1991) [11] argument for sustaining diversity in learning systems.

5. Conclusion
Making use of a simulation model, we examine how the locomotion and assessment imitation strategies perform in changing environments. We find that assessment outperforms locomotion in a stable environment; however, increases in the magnitude and frequency of environmental changes increase the attractiveness of locomotion imitation strategy over assessment. When environmental changes are frequent and moderate, locomotion imitation is more effective in maintaining the lead. We reveal that the relative effectiveness of locomotion is driven by the trade-offs between exploration and exploitation. Complex problems make it difficult to rely only on assessment. This is because when benchmarking is changing, even small fluctuations in environment may lead to significant performance penalties. What is more, assessment precludes the potential for subsequent improvements through local search. Especially in a frequent and moderate dynamic environment, locomotion who keeps changing choices and learning from the resulting performance feedback can get a better final performance level. Our insights extend research on the imitation-performance relationship, which has largely focused on legitimacy- and learning-based arguments [12], and address calls to incorporate the notion of environmental uncertainty more completely into management theory [13].

A limitation of this study is that we design locomotion and assessment separately. According to self-regulation research locomotion and assessment can work together in an interdependent manner. High achievement needs both a correct direction to target (high assessment) and a commitment consistently for a movement (high locomotion). So there is an interesting opportunity for future
research could be to design searching strategy combined both locomotion and assessment. Furthermore, we didn’t consider the co-evolution of self-regulation and environmental change which can take many forms. This dynamic process would end up with finding a perfect independence and it is worthy of further development.

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