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Drug discovery: are productivity metrics inhibiting motivation and creativity?

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With a productivity gap in pharmaceutical research and development, and increased industrialization in both areas, an increased need for precise indicators of productivity has emerged. Measuring scientists' performance can impact the way the tasks are performed and the level of motivation of an individual. This is a crucial aspect when key performance indices of other performance metrics are to be defined within an organization. Motivation is a main driver of creativity and should, therefore, not be compromized by a need to measure productivity. This paper is based on 120 interviews in over 50 companies from 2005 to 2008. The results suggest that the level of detail at which performance should be measured depends on the level of industrialization that a technology falls within. Performance metrics are a means for feedback to individuals. Furthermore, we show that the level of motivation is not directly correlated to the level of detail that a group's performance is measured at, but instead that it varies from person to person. Consequently, we suggest that the level of detail of performance measurement and the motivation profile of the scientists need to be aligned. This is an important aspect to consider when measuring performance.

Introduction

Sources of innovation differ depending on the stage of maturity of the organization. As highlighted by Ullman and Boutellier [1], larger research organizations go hand in hand with a shift from personal initiative to a need for coordination. Quinn and Cameron [2] described the four stages of this evolution as (a) the entrepreneurial stage; (b) the collectivity stage; (c) the formalization stage and (d) the elaboration stage.

According to Quinn and Cameron, these stages imply different sources of innovation from (a) the owner; (b) employees and managers; (c) a separate innovation group and (d) an institutionalized R&D department.

In large organizations with a high need for productivity in research, institutionalization seems to be only partially beneficial for innovation.

Because of increasing merger and acquisition activities – integrating biotechnology firms into larger research organizations and also within large global research organizations – various cultures and departments belonging to different stages of the evolution described above need to coexist. Thus, the entrepreneurial stage, at the laboratory level, has to cohabit with the formalization and elaboration stages and their respective sources of innovation at the departmental level.

Drug discovery involves a large number of specialists in diverse areas engaged with numerous scientific communities and technologies. These technologies are in various stages of maturity. March [3] refers to an evolution of technology maturity from exploration to exploitation. Abernathy and Utterback [4] describe the technology life-cycle as an evolution from product innovation over dominant design to process innovation (Fig. 1) in three phases: (a) the fluid phase, where extensive experimentation with product design occurs; (b) the transitional phase, where process innovation prevails over product innovation and (c) the specific phase, where product and process innovation decrease and emphasis is set on cost reduction.

Monoclonal antibodies (mAbs), interference RNA (RNAi) and genomics or proteomics belonged to the fluid phase in the 1980s. Now, according to our interviews, RNAi and mAbs have emerged

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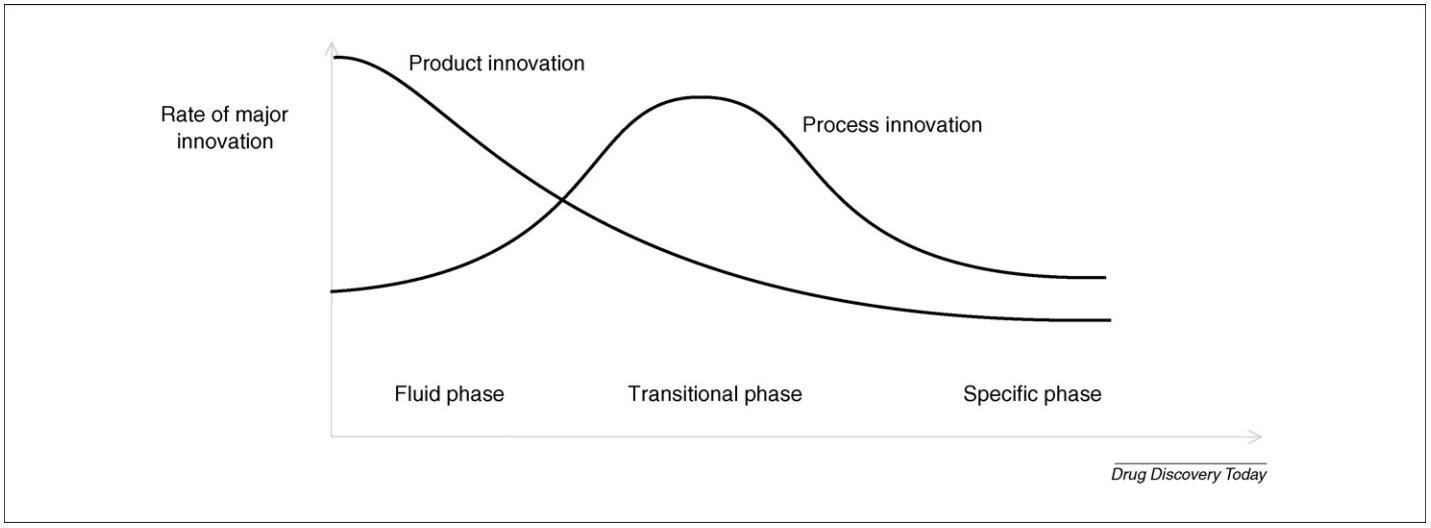

FIGURE 1

Abernathy and Utterback [4] describe the technology life-cycle as consisting of three phases. During the fluid phase, the rate of product innovation is high and little attention is given to process innovation. The number of product varieties is high because a lot of experimentation with product design takes place. The fluid phase then gives way to a transitional phase, where product innovation decreases and process innovation prevails. During this phase a dominant design typically emerges that has been accepted in the market place or specified by regulators. Some technologies then enter the specific phase, where product and process innovation lose momentum and focus is mainly set on reducing cost.

as dominant designs, where extensive process innovation occurs. This is the transitional phase. Finally, *in vivo* drug metabolism and pharmacokinetics (DM–PK) assays could be classified in the specific phase, where product and process innovation have slowed down.

The fluid phase is often performed in universities and biotechnology firms where high risk is tolerated. The pharmaceutical industry picks the technologies that then often become a dominant design, for example, combinatorial chemistry or HTS. Technologies that have reached the specific phase are candidates to be outsourced to countries with lower labor cost, because the task can easily be specified and quality can be measured [5].

With this evolution into more process-driven activities emerges an increased need to measure processes more precisely, to gain efficiency. The reason is that, with each point of measurement, one can limit the number of possible sources of waste, akin to localizing a leakage in a pipe. With more detailed measurements of performance arises a challenge to keep researchers motivated and creative. This mix of innovation sources and levels of bureaucracy and industrialization makes it even more challenging to measure performance, especially in large organizations. Furthermore, Ullman and Boutellier [1] highlight differences in performance measurement between different laboratories at the same hierarchical level, depending on whether the activity is creativity- or process-driven. Accordingly, within the hierarchy of an organization, performance measurement varies both vertically and horizontally.

Different activities need different metrics

Measuring performance can affect the investigated individual's actions. Management goals are set by metrics or key performance indices (KPIs) that should contribute to individual, group and company strategic goals. Depending on the activity, it is more or less easy to find an adequate metric. According to Roberts' [6] 'simple agent theory' [7], performance metrics need to be informative, reflecting the individual's choice of effort. Metrics influence what an individual or a group does and how they accomplish a task. Hence, with metrics, management has an impact on individuals' delivered performances. Motivation is the *sine qua non* for creativity [8] and initiative. Thus, impact on motivation needs to be considered when measuring performance, assuming that creativity and individual initiative is beneficial to the firm. The performance of some activities can be measured precisely, whereas the performance of others can only be determined vaguely. For example, the activity of a high-jumper compared with that of an ice skater is instructive. The performance of a high-jumper is measured by the height he or she can jump. The ice skater is asked to make a triple spin, which involves speed, a number of rotations, staying centered, keeping in control and elegance. The first four markers of a successful triple spin can be measured in absolute terms, but elegance is a subtle variable assessed by experts, based on their experience and preference. Similarly in science some activities are predictable and measurable in absolute terms, whereas others can be assessed only by experts [1].

Detail of measurement is decisive

We define the 'detail of performance measurement' as the degree to which a process is predefined by the measurement. Consequently, if the detail of a performance metric is high, there is limited space for an individual's own initiative on how to perform the expected task. According to Hackman and Oldham [9], autonomy in configuring how a task should be carried out is an important component to motivation.

Measuring performance is often regarded as an instrument panel for managers, although its primary aim should be to give objective feedback to (and within) the organization. Feedback is also a major driver for motivation [9]. If not measured at all, an

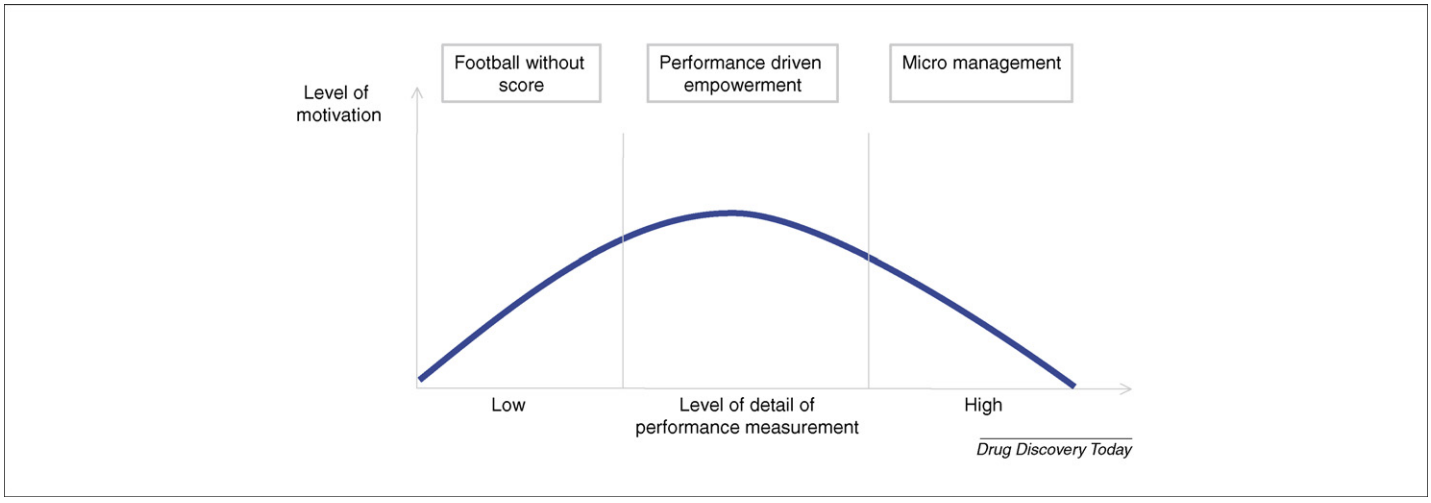

FIGURE 2

A high level of measurement detail restricts an individual's autonomy in how to perform a task, and autonomy is an important driver of motivation. A low level of measurement detail inhibits motivation, because feedback is a driver for motivation. Hence, the level of detail at which an individual's performance is measured affects the level of her motivation to perform a task.

individual feels that the task he or she is doing is not important. Feedback is a means for recognition, which is a major driver for many scientists. Similarly, when playing football people are more motivated when the score is counted, as opposed to if the result does not count. If performance is not measured, there is no benefit to work hard. At the other extreme, if performance is measured at a highly detailed level micromanagement reigns and employees begin to feel controlled and resentful of a lack of autonomy.

We therefore assume that somewhere between these two extremes exists an optimum – a detail of performance measurement that we will call ''performance-driven empowerment'', where an individual's motivation is at its highest (Fig. 1).

We assume that this maximum depends on a person's intrinsic motivation and, thus, cannot be influenced by external incentives [8]. Our hypothesis is that this optimum differs from one person to another (Fig. 2).

Method

We interviewed scientists in over 50 companies that performed numerous activities involved in the drug discovery process. In total, we carried out 120 interviews in GPCs, CROs and biotechnology firms in China, India, USA and Europe. A case study method [10] was used. We asked (a) how their performance was measured, (b) if they felt this was a fair assessment, (c) if they felt they were limited in their personal initiative due to a restrictive performance system, (d) if the system gave them the needed feedback to improve and (e) if the system impacted their motivation in a positive or negative way. These questions were used as guidelines and not as a standard survey.

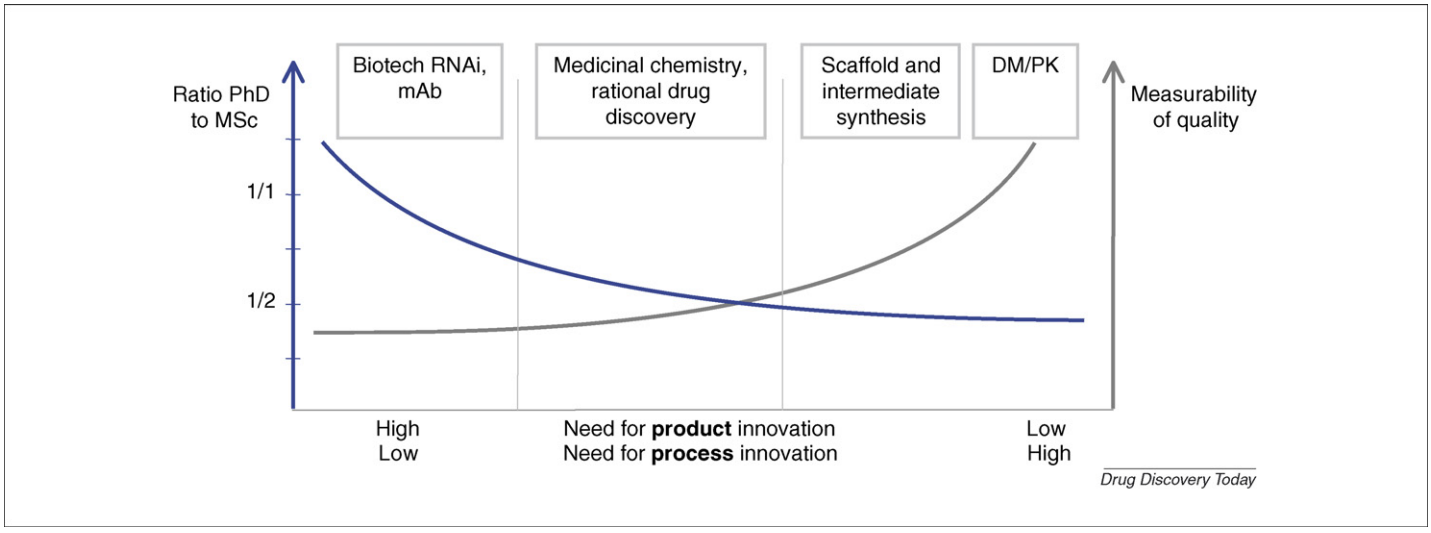

FIGURE 3

Measurability of quality, ratio of PhDs to MScs, seems to be related to the level of industrialization of a technology. The higher the degree of industrialization of a technology, the better the performance of a process applying it can be measured. Furthermore, when a technology evolves, from an early stage of maturity to a higher degree of industrialization, the ratio of PhD to MSc scientists decreases.

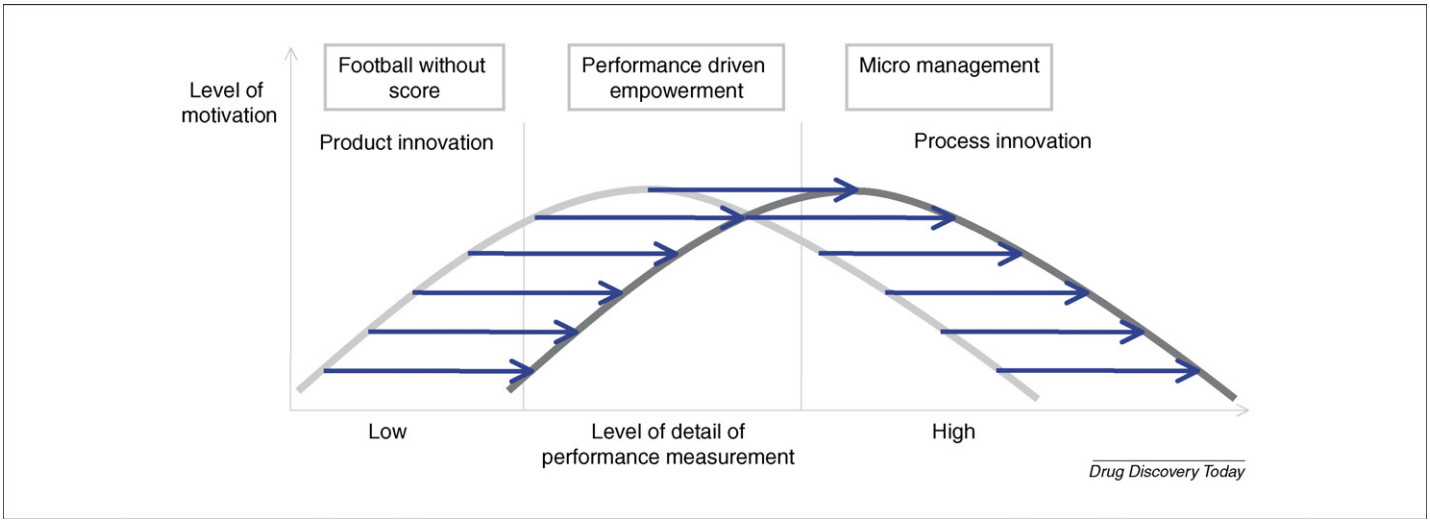

FIGURE 4

As technologies mature from the fluid stage, with a low level of industrialization, into a transitional stage, where process innovation prevails, the detail of performance measurement increases. To avoid scientists losing motivation during this change, it is important to put together a group with a motivation profile that allows more detailed performance metrics.

Results

In our sample of companies we noticed different ratios of PhDs to MScs within groups, depending on the activity performed. Given high levels of industrialization within a group, specialists were able to predict and plan a process in a rigorous way. Thus, prospective criteria were defined as quality properties. There was consequently less need for expert assessment when measuring performances, and the ratio of PhD to MSc scientists within the team decreased with the level of industrialization. Therefore, PhD-level scientists were not required to perform tasks requiring a BSc or MSc level of competence (Fig. 3).

A majority of activities belong to a gray zone between low maturity and commodity science and are often kept in-house (Fig. 1). Ullman and Boutellier show a difference between innovation studios and process factories. Both needs to be integrated in a research organization to reach high efficiency. Consequently, some activities need to be measured in a detailed way and performed by technology experts, whereas others need to be measured with a more holistic perspective and performed by science experts.

We found motivated people at different levels of measurement detail from very high to very low levels of detail. Some were happy with high levels of autonomy and little supervision. Others were more process driven and wanted precise task descriptions, clear expectations and detailed performance metrics. We could not find any evidence that highly detailed performance measurement systematically inhibits motivation. The senior scientists were more reluctant toward performance measures than junior scientists. We also noticed regional differences. In the Chinese companies visited the enthusiasm for performance metrics was higher than in India, USA and Europe. Chinese companies were, in general, process oriented and risk adverse. They measured performance by turnaround times in analytics, and by the number of synthetic steps per person per week or the number of compounds per person per week in chemistry. None of these metrics reflect any advancement towards a successful drug, but it releases the scientist from any personal responsibility in terms of advancement towards a new drug. The only concern is to perform a process (timely and qualitatively) precisely. American and European scientists were measured primarily by their impact on a project. Because of serendipity in research, some thought this factor could inhibit motivation during times when no molecules were successful. They felt that there was no direct correlation between their dedication and the way they were measured.

The scientists in India were more innovation driven. They wanted to have an impact on the progress of a project and take part in the problem-solving process. Akin, at the company level, the Indian firms were eager to share risk and profit with their clients. The Indian companies had been operating for a longer time and the chemical expertize was high.

These results let us presume that, when a technology gets more mature within a company, the mix of scientists within the responsible team needs to be adjusted. The level of performance detail of the activity performed (Fig. 4) needs to correspond to the motivation profile of the scientists.

The results also suggest that experience and culture influence the impact that performance measurement has on motivation.

Expertize within a technology often results in the ability to optimize it. One could therefore expect that experts need more autonomy than novices within their tasks, and therefore less detailed performance measurements. This challenge is often solved naturally through increasing responsibility within the organization. When this promotional step does not occur, for example in flat hierarchies, one could expect lower motivation among experienced employees or higher turnover rates of employees.

Concluding remarks

To keep motivation high within research groups, management needs to consider each individual scientist based on his or her need for detailed and frequent feedback. Each activity needs to be staffed with scientists whose motivation curves reflect the level of industrialization of the activity they are responsible for. Because

the level of industrialization changes over time, restaffing is required to keep a high efficiency within the research group and to maintain a balanced cost structure. The motivation curve of highly entrepreneurial individuals with a wealth of experience and higher education seems to have its maximum at a lower level of detail than it does for individuals with less experience and less education. Thus, one should not be hesitant to measure performance, even in research.

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