

Goorha, Prateek; Potts, Jason

**Article**

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Journal of Global Entrepreneurship Research

**Provided in Cooperation with:**

Springer Nature

*Suggested Citation:* Goorha, Prateek; Potts, Jason (2016) : Awareness in innovators: From "outside the box" to "inside the bubble", Journal of Global Entrepreneurship Research, ISSN 2251-7316, Springer, Heidelberg, Vol. 6, Iss. 15, pp. 1-9, <https://doi.org/10.1186/s40497-016-0058-7>

This Version is available at:

<https://hdl.handle.net/10419/196980>

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METHODOLOGY

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# Awareness in innovators: from 'outside the box' to 'inside the bubble'

Prateek Goorha<sup>1\*</sup> and Jason Potts<sup>2</sup>

\*Correspondence:  
goorha@sent.com

<sup>1</sup>Independent, Lexington, MA  
02421, USA  
Full list of author information is  
available at the end of the article

## Abstract

Innovation is sometimes perceived as a linear and sequential process, and at other times as multidimensional. Based on the common thread of 'awareness' that grounds many theories on innovation, we analyze the idea that a flexible informational awareness accounts for both perceptions within the same overall innovation strategy. To show this, we propose using a simple theoretical setup that yields an intuitive and tractable visualization - in the form of thought bubbles - for the process of innovation. We discuss the application of this visualization to the process of idea search and to the types of knowledge commons.

**Keywords:** Innovation, Sequentiality, Multidimensionality, Ideas, Thought bubbles, Knowledge commons

## Background

Chris Anderson's *The Long Tail*. Malcolm Gladwell's *David and Goliath*. Jaideep Prabhu, Navi Radjou and Simone Ahuja's *Jugaad Innovation*. Clayton Christensen's *The Innovator's Dilemma*. Each, a riveting read.

A beautiful and simple message is shared across them: *awareness* is the cornerstone of strategic thinking. In the specific context of innovation, they owe a debt of gratitude to the tradition of Austrian economists – Kirzner's *Competition and Entrepreneurship* being the flagship – who made vivid the idea of entrepreneurial alertness as a fundamental quality of an individual's conscious thinking, essentially enabling entrepreneurial ability within *any* market participant.

This is a strong statement, and yet, research on innovation has examined the ideas of alertness and awareness largely only tangentially. There is, admittedly, a wealth of literature that pertains to the *diffusion* of individual and collaborative innovations. While most recent advances on this topic adopt a network-theoretic approach<sup>1</sup>, it generally owes a great deal of intellectual debt to the innovator-imitator approach in Bass (1969) and the sequential stages for the innovation process proposed in Rogers (1962). While the idea of examining the innovator's awareness is indubitably related to the process of innovation diffusions, we submit that, since it is conceptually *prior* to any diffusion process, it deserves more attention in its own right. The reason for awareness being somewhat marginalized as a candidate for theoretical investigations is possibly attributable to the fact that it occurs within the minds of innovators, and is consequently perceived as being more aptly suited to the fields of cognitive psychology and neuroscience.<sup>2</sup>

In this article, therefore, we develop the idea of awareness from a somewhat different perspective. In the second section of this paper, we introduce the basic structure of pursuer-evader games as the impetus for conceptualizing the awareness of an innovator. This modeling framework permits the basis for an intuitive visualization, which we discuss in “Results and discussion” section, and show how it characterizes the gist of the model and can be extended to study innovation in collaborative contexts.<sup>3</sup> It involves replacing the box – that, unhelpfully, one must ‘think beyond’ — to a sphere that captures the innovator’s strategic thinking process to begin with.

The benefit of this approach, besides the useful parallel between the intuitive imagery it enables based upon the underlying model, is that it suggests a unifying framework for the analysis of awareness. For example, the framework suggests why certain channels of learning on a network may yield more insight than others, or why a certain search for idea might be relatively more fruitful than others. Moreover, it enables providing structure to the burgeoning literature on innovations arising from collaborations occurring in open-access institutions that operate in the shadow of markets, such as knowledge commons.<sup>4</sup> We explore several of these issues in this paper.

It is perhaps useful to begin by visualizing the process of innovation as nothing more than the accumulation of ideas. Ideas are ‘infinitely expandable’<sup>5</sup>, a term that implies more than the simple fact that ideas are accumulated with increasing returns. It underscores the fact that this expansion transpires in infinite dimensions as well.<sup>6</sup> It is, therefore, unsurprising that strategy should have multiple dimensions as well.<sup>7</sup> Strategy, seen as *trajectories of ideas* need not be unique. The most intuitive manner of building a theoretical construct on this basis is to do so by working the problem in three dimensions; indeed, ideas are very often represented in Euclidean space in any case.

To begin, let us imagine a group of innovators working together. The approach they adopt to innovation is one of exerting efforts and employing resources based upon a process that incorporates their impressions on how much ground they need to cover in order to achieve a target. This is a reasonable enough manner to proceed given the fact that the desire and demand for innovations are adjudged by an underlying comparison to an extant outcome. Through time, the discrepancies that develop between an *ideal* innovation that the group hunts for, and the *satisficing* extant alternative begins to accumulate through ‘memories’. Indeed, that institutions have memories (or, indeed, a lack thereof) just like people do is hardly a sensationalist claim. It is this burgeoning reserve of memories that motivates even the incumbent innovators to consider the effects of the innovations that their rivals engender, even if their memories permit a different threshold before exertions need be made. Goliath plays a different game to David’s, just as the incumbent firm fails to recognize that the game has altered.

To these ideas of infinite multidimensional growth and memories, we add a third premise: Innovations are a result of a sequential process in the accumulation of ideas of two varieties: basic and complex. Complex ideas require the prior completion of basic ideas before they can be accessed (in other words, complexity is in the eye of the beholder), and that the entire process is governed by a resource constraint.<sup>8</sup>

Together these ideas suggest an insight on awareness. That it must be intrinsically related to a foresight on *where*, along the sequence of ideas, does the next innovative idea emerge.<sup>9</sup> And that, answering this question of ‘where’ necessarily also involves answering a question on *which* of the trajectories to select among an infinite set. The aspects of

multidimensionality and sequentiality in innovation are thus not mutually exclusive. In other words, given the resource constraints and proportions of basic to complex ideas, awareness that the low-hanging fruit are often on the other side of the trees is what 'jugaad' relates to.

In the following section, we introduce the methodological background for a pursuit-evasion game that provides the impetus for modeling awareness in our context of innovators; this also permits us to introduce the ideas of memories and of complexity in strategy more formally. We end the section by introducing the basis for our proposed imagery of thought bubbles for an innovator. In the subsequent section, we develop this imagery with the help of some figures and suggest how they can be used to understand sequential innovations in the context of increasing conceptual complexity. Given the collaborative nature of most innovative activity, we then use the idea of thought bubbles to provide a taxonomy for knowledge commons; this helps distinguish between the nature of awareness that the participants of such commons possess.

### Methods: Grounding awareness in a game of pursuit

We make our thinking on this subject clear with the use of a simple modeling framework, borrowed from the class of models known as pursuit-evasion games. The applications of such games – as the name suggests – has traditionally been to issues of security in a variety of contexts, ranging from watchmen at an art gallery to military tactics and missile guidance. The aspect of awareness is a natural and intrinsic component of such models, since either the pursuer, evader, or both, are expected to inform their actions on the basis of their awareness of the environment. Thus, in a two-dimensional representation of an art gallery, for example, it has been shown that an entire gallery with  $n$  vertices can be made observable by  $n/3$  watchmen (Chvatal 1975). It was earlier, in the 1950s at *RAND*, that such games were examined as differential games in the context of war. An early and seminal contribution based upon this research is Isaacs (1965).

A number of elements are relevant to pursuit-evader games that help characterize the idea of awareness concretely, including the information set of the pursuer and the evader, whether the evader is visible or not, and the numbers of each. While the particulars of these models are not of direct relevance to our analysis, they provide a rather useful mooring for the analysis of entrepreneurial awareness. As such, we adumbrate the overall approach and refer the interested reader to the vast literature that underpins the structure.<sup>10</sup>

For our context, we can imagine that an *ideal innovation*,  $\iota$ , stands in for the elusive object. We can make a simplifying assumption that the innovation can be discovered within an  $n$ -dimensional Euclidean field of ideas; it is perhaps useful to think of this field as an idea space. The discovery of the innovation can be imagined as being dependent upon a location along a trajectory of efforts expended by the innovator, who represents the pursuer.

The difficulty of the discovery can be envisaged as being dependent on some measure of dynamic complexity,  $x$ , that is described by a process

$$d\kappa/dt = \dot{\kappa} = x. \quad (1)$$

We can further imagine members of a research group,  $G_i$ , exerting efforts over time,  $s_i$ , in search of the innovation, so that

$$d\alpha_i/dt = \dot{\alpha}_i = s_i. \quad (2)$$

If the group comprising  $n$  individuals,  $i = (1, 2, \dots, n)$ , has a horizon at  $t = \tilde{t}$ , then the search efforts are specifiable simply as

$$s_i = s_i(t); \quad 0 \leq t \leq \tilde{t}. \quad (3)$$

To emphasize the idea of the group working on the basis of an informational awareness of their environment, let us introduce the idea of *memories* by requiring Eq. (3) to follow

$$\left( \int_0^{\tilde{t}} |s_i(t)|^\beta dt \right) \leq \theta_i^\beta, \quad (4)$$

where  $\beta \geq 2$ , and  $\theta > 0$ .

Likewise, in order to capture the notion of increasing difficulty of innovations when the low-hanging fruit have been exploited, we suggest that the complexity of the idea innovation *rises* through the horizon in the space of ideas. We can, therefore, write analogously that

$$x = s(t); \quad 0 \leq t \leq \tilde{t}, \quad (5)$$

and, that

$$\left( \int_0^{\tilde{t}} |x(t)|^\beta dt \right) \leq \phi^\beta, \quad (6)$$

where  $\phi > 0$ .

Equations (1–6) characterize a setup where an innovation is being ‘chased’, much like it would be in a pursuit game; much depends on an arms race along the path where efforts need be redoubled as the complexity of the innovation mounts.

The ideal path of innovation for a research group would involve a strategy that the group can feasibly adopt and that ensures the achievement of innovations. For an individual researcher,  $G_i$ , this essentially just requires the innovation problem to be solvable. We can state this notion with the help of a system

$$\left. \begin{aligned} \dot{\alpha}_i &= S_i(\alpha_i, \kappa, \theta_i(t), x(t)); \\ \alpha_i(0) &= \alpha_{i0}; \\ \dot{\kappa} &= x(t); \\ \kappa(0) &= \kappa_0, \end{aligned} \right\} \quad (7a)$$

where  $S_i(\alpha, \kappa, \vartheta_i, x) \rightarrow \mathbb{R}^n$  and  $\vartheta_i \rightarrow [0; \theta_i]$ . Here  $S_i$  is the strategy that provides a solution for any complexity,  $x(t)$ , in the innovation problem.

We are, however, interested in the dynamic choices over strategy that the researcher makes in search of the innovation. The efficiency of this sequence of choices has interesting implications in terms of what we understand to be the awareness of the researcher. Contrasting across individuals, firms, or industries operating in different environments is confounded by treating the complexity of innovations as invariant to such nuances; this rigid trajectory is often a feature in much popular discussion on innovation, and is hardly justifiable.

Dealing with varying complexity in this setup, however, is rather simply achieved; as a parallel to the system in (7a), we would have

$$\left. \begin{aligned} \dot{\alpha}_i &= S_i(t); \\ \alpha_i(0) &= \alpha_{i0}; \\ \dot{\kappa} &= X(\alpha_1, \alpha_2, \dots, \alpha_n, \kappa, \theta_1(t), \theta_2(t), \dots, \theta_n(t), \phi(t)); \\ \kappa(0) &= \kappa_0, \end{aligned} \right\} \quad (7b)$$

where  $X(\alpha_1, \alpha_2, \dots, \alpha_n, \kappa, \vartheta_1, \vartheta_2, \dots, \vartheta_n, \gamma) \rightarrow \mathbb{R}^n \times \mathbb{R}^n \times \mathbb{R}^n \times [0, \theta_1] \times [0, \theta_2] \times \dots \times [0, \theta_n] \times [0, \phi_n]$ . One can see the complexity,  $X$ , of the innovation in two ways – from a perspective of scientific feasibility or a representation of market desire for an innovation.

With this dynamic process in place, we can now characterize the research group's awareness in its search for an ideal innovation over a horizon by using the imagery of a *thought bubble* that demarcates the domain of feasible outcomes.

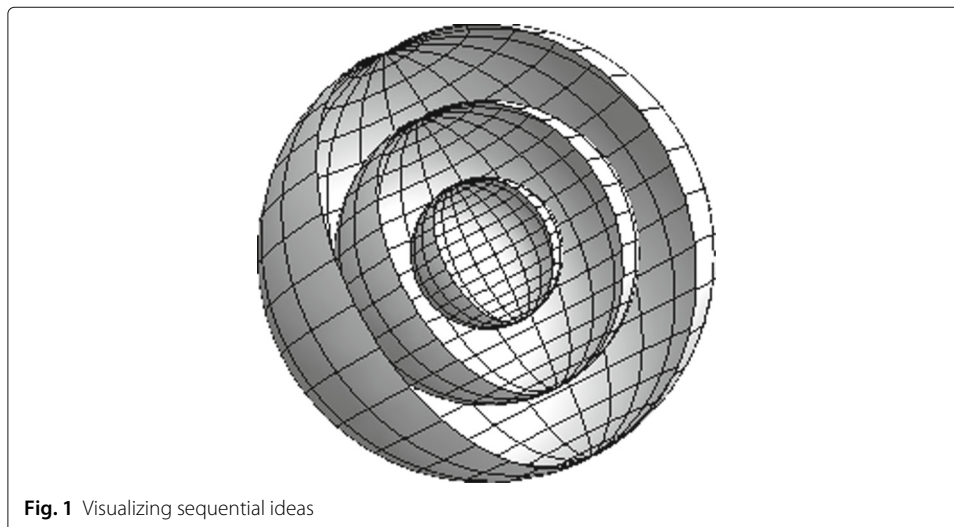
This awareness bubble  $A(\alpha, a)$  is a sphere, with a center at  $\alpha$ , and with some *radius of awareness*,  $a$ ; we can write, for any given researcher, that

$$A(\alpha, a) = A(\alpha_{i0}, \theta_i t^{(1-1/\beta)}). \quad (8)$$

The imagery is best assessed graphically, and we turn to this in the following section.

## Results and discussion

Figure 1 shows thought bubbles, neatly placed in a concentric arrangement in order to represent a sequential process of innovations. The idea of an innovation *path* emerges from even a cursory look at the figure. For any given path, the discrete boundaries of the bubbles represent waypoints along the sequential process of the accumulation of ideas for a given possible innovation, and each bubble represents the completion of a set of necessary ideas *before*, rather like a game, the next level might be attempted. Inexorably outwards, ever boldly to the next surface, marching towards the frontiers of science. The image is one of scientific progress in the creation of knowledge.



**Fig. 1** Visualizing sequential ideas

The progress towards innovation, however, usually commences with search over a foundational set of ideas. Initially, the search process is *unmoored* within the class of ideas; however, once the initial idea has been settled, search for the next idea then becomes *moored* to it. Search patterns for a given thought bubble for unmoored and moored search are illustrated in Figs. 2 and 3. A useful example for this might be thinking about a recipe for dinner. The unmoored search permits freer thought. Once, however, the essential ingredient has been settled, the next idea is then moored to it.

We can also conceive of *collective* awareness as being genuinely spatial by adopting the language of knowledge commons. As with all resource commons, knowledge commons feature open access to a resource that is held in common by its members. In the case of knowledge commons, however, the resource is knowledge. Therefore, while the aspects of governance are shared across them as concerns, the emphasis in analyzing knowledge commons shifts away from issues of sustainable use and depletion of the resource toward organizing the information resource to generate super-additive value.

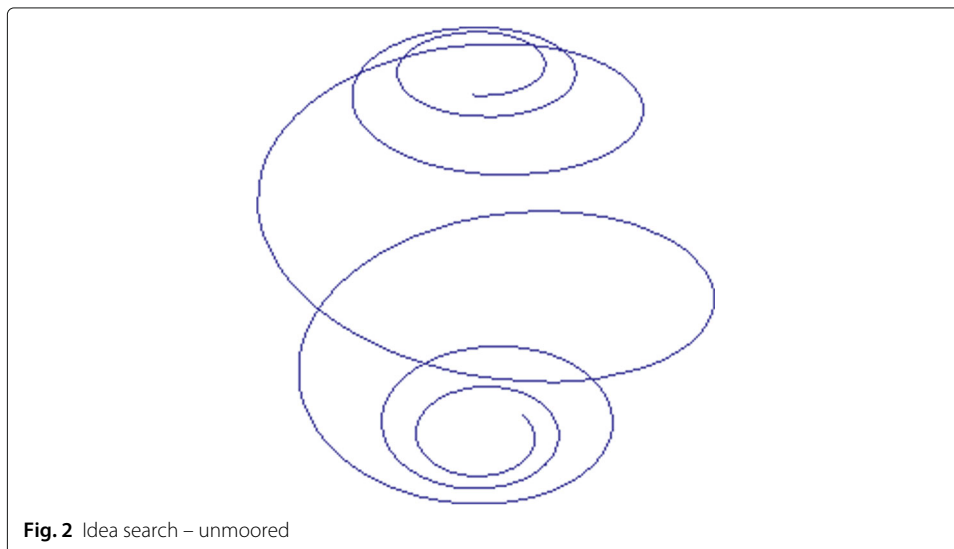
It is possible to conceive of a taxonomy of knowledge commons based upon the visual imagery of the thought bubbles. Four such broad categories of commons can be imagined.

1. *Pure Knowledge Commons*

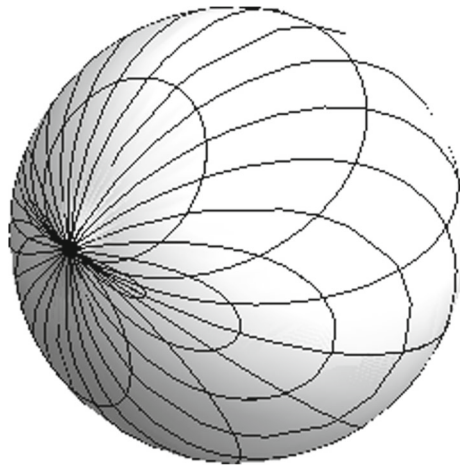
Here we only need imagine an expanding bubble over time. Through an increase in both participation and effort in a pure knowledge commons, we would expect growth in knowledge representable as the bubble that inheres to that form of knowledge resource. As an entire class of examples, one can consider the scientific method and the disciplines that it enables.

2. *Discovery Commons*

These types of knowledge commons can be visualized as amalgamations of overlapping pure knowledge that seek to associate across knowledge resources in order to enable new genres of discoveries. A visualization of this is shown in Fig. 4. Examples would include an initiative that expressly seeks to encourage the commixing of disparate ideas, such as 'coworking spaces' enable. Institutions and



**Fig. 2** Idea search – unmoored



**Fig. 3** Idea search – moored

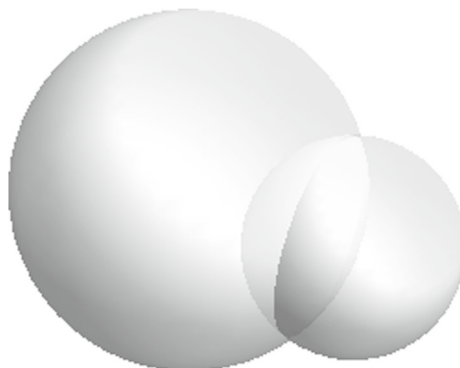
firms see merit in this approach too. Harvard University's *Institute for Quantitative Social Science* and the firm *IDEO* stand as key examples.

3. *Processing Commons*

These are commons that can be seen as emerging from sets of ideas that are 'cycles' in a discovery commons, that is complete paths through all relevant discovery commons. Processing commons, therefore, contain paths of ideas that can then be seen as being replicable and verifiable more readily (learnt and taught from the perspective of both pure knowledge commons). This makes them very useable in eventual production. As such, one can also envisage processing commons as pure knowledge commons that are brought about by entrepreneurial effort. Based on the 'cycle' of public-private encryption and decryption technologies, that date back at least to the 1970s, and a host of other ideas (finance, the blockchain is a good example here).

4. *Jugaad Commons*

Given a processing commons, we can also imagine a jugaad commons, where complete paths of ideas, or 'solutions', that are members of the respective pure knowledge commons exist as approximations of a fuller solution at lower



**Fig. 4** Visualizing discovery commons



cost/effort. Thus, here participants adapt the problem that characterizes a pure knowledge commons and employ in a processing commons to solve a different problem. Examples would include grassroots innovations, hackerspaces, tinkers, and hobby clubs, where solutions are often adapted for ingenious applications that serve as alternatives to the market.

## Conclusion

A simple internet search on the phrase suggests that the metaphor of ‘thinking outside the box’ is common in the parlance, both in academic literature and in practice. Its endurance is doubtless rooted in its ability to engender pithy exhortations for ingenious and creative thinking. However, it is not an exceptionally useful imagery when it comes to conceptualizing the processes behind the achievement of a complex discovery through effortful thinking generally. It also fudges over the notion of how ideas are sequentially processed towards the achievement of an innovation or discovery, and cannot say much altogether about the problem of when it might pay to look within the box or to look at different boxes jointly.

In the second section of this paper, the general framework of a pursuit-evader game was presented as a promising candidate for the examination of awareness among innovators for three principal reasons. First, it provides a natural premise for the analysis of search in three dimensions, which is amenable to the context of ideas – and knowledge, generally – that are multidimensional in their nature. Second, such games can be adjusted to accommodate for the resources of innovator or innovators, and the complexity of the problem being addressed. Third, and perhaps most usefully, such games lend themselves to intuitive visuals, some of which were illustrated in “Results and discussion” section of this paper, that assist conceptualizing the process of awareness in practice.

Using the metaphor of a thought bubble as developed in this paper, we can examine the idea of *why* pushing toward the outermost surface of the bubble need not necessarily be the appropriate objective. The ability that thought bubbles gives us for organizing our thinking about the process of idea search and of collaboration in a variety of types of knowledge commons is a useful benefit.

## Endnotes

<sup>1</sup> The theoretical underpinnings of such models are subtly different, but a general approach is presented in Jackson and Yariv (2005).

<sup>2</sup> Zaidel (2004), for instance, proposes a neuroanatomical approach for analyzing creativity, identifying four types of innovation based on two types of information and two modes in which the brain processes it.

<sup>3</sup> A recent investigation of how innovations arise in the collaborative context of bat and ball sports, the interested reader is referred to Goorha (2016).

<sup>4</sup> See Allen and Potts (2016) for a useful introduction to the idea of innovation commons. More generally, see Hess and Ostrom (2011) on knowledge commons. Lerner and Tirole (2003) suggests some difficulties in using standard economic reasoning in examining the incentives for peer production in the open access institution of open source software.

<sup>5</sup> This idea of idea expansibility can be found in the writings of Thomas Jefferson. Koch and Peden (1944)

<sup>6</sup>See Kline (1985) for an examination of a multidimensional approach to innovation. A large variety of papers suggest a combinatorial approach to the generation of ideas. An excellent review can be found in Weitzman (1998).

<sup>7</sup>This has not gone unrecognized in the literature; Frery (2007) is a particularly interesting example.

<sup>8</sup>This message drives the analysis in Zaltman et al. (1973).

<sup>9</sup>In a thought-provoking article in this journal, King and Lakhani (2013) discuss opening various aspects of the idea to innovation process. By doing so, however, they also suggest how a variety of firms view the role of 'external' sources of assistance in the sequencing of ideas.

<sup>10</sup>We found Petrosjan and Mazalov (1996) and Ibragimov (2005) to be particularly useful to our conceptualization of this methodology.

#### Authors' contribution

This article resulted from several discussions between the authors. PG conceived of the idea of awareness to be bolstered by the methodological framework reviewed here and JP contributed toward refining the context and application. Both authors read and approved the final manuscript.

#### Competing interests

The authors declare that they have no competing interests.

#### Author details

<sup>1</sup>Independent, Lexington, MA 02421, USA. <sup>2</sup>RMIT University, Melbourne, Australia.

Received: 18 May 2016 Accepted: 27 October 2016

Published online: 21 November 2016

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