BIASES AND HEURISTICS IN R&D PROGRAM MANAGEMENT DECISIONS

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Abstract
Whenever a program manager is faced with a programmatic decision, his or her beliefs and experiences bias how he or she views the decision and what information is utilized to help arrive at a final alternative. These biases can either be intentional or unintentional. Intentional biases are a result of the program manager's willful decision to bias the results of their assessment, perhaps due to a preference of one alternative over another. Even without intentional biases to account for, all human beings have unintentional cognitive biases that affect the information that is elicited from them. These cognitive biases include the availability heuristic, conjunction fallacy, representativeness heuristic, and anchoring. These biases can be both hurtful and helpful to the decision process. These relationships and their role as both a help and a hindrance to program management decisions within the context of an R&D environment will be explored in this paper.

Key Words
Research and development, biases, heuristics, R&D program management

Introduction

Research and development (R&D) is a key driver of societal technological innovation. The innovation process has been conceptualized as either a: 1) linear (OECD, 1993; Ramsey, 1986, p.7), or 2) nonlinear process, consisting of basic research, followed by applied research, then by development and eventually commercialization. Basic research refers to "quests for basic understanding" thereby producing a "continuing stream" of new knowledge and fundamental ideas. Among these new ideas, a few that show technical feasibility are screened towards applied research, then narrowed further towards more detailed development. The remaining few that show combined technical as well as market feasibility will eventually be adopted by innovating firms to be transitioned into commercial markets. It is clear that even the linear model of innovation is a complex process requiring significant effort, both from a programmatic and a research standpoint.

For the purposes of this paper, those who provide sources of funding for research (private organizations, private foundations, public-sector agencies) are referred to as sponsors, while those that seek to obtain funding for the purposes of undertaking sponsored research are referred to as researchers (or research organization at the enterprise level). This paper focuses on the analysis of sponsors within the context of profit-driven R&D enterprises. Several issues arise in the process of establishing a successful R&D organization; among these is large capital requirements and inherent technological risk (Braunstein et al., 1980). At the heart of sponsor funding decisions are individual program managers who must make programmatic decisions (pursuing a new program or project, abandoning a current program or project, involving subcontracting, increasing/decreasing resources, selecting between alternative projects/technologies). Since these decisions originate with individuals, who are prone to errors in judgment and decision making, this paper focuses on the identification, understanding and resolution of these mistakes.

Whenever a program manager must make a programmatic decision within a research and development (R&D) organizational context, their beliefs and experiences bias how they view the scenario and what information they choose to utilize in their decision. These biases can take the form of either intentional or unintentional biases. Intentional biases are a result of the program manager's willful decision to bias the results of their assessment. This willful deceit can occur due to preference of one alternative over another. The program manager may prefer one alternative over another due to personal relationships the individual has. An example would be a research organization that the program manager used to work for, that he/she has a significant vested interest in seeing that organization continue to succeed. If the program manager were to have an interest in seeing this organization succeed, then the program manager may intentionally bias their decisions by providing an unbalanced amount of funding to that particular research organization. Alternatively, the program manager may have a reason not to prefer a particular

research organization and may intentionally bias the results accordingly (e.g. the program manager has a personal problem with an employee of a particular organization or he/she was fired from an organization). Typically, these intentional biases are easier for an outside observer to recognize as strong connections between the program manager and his/her intentionally biased choice (such as significant financial or personal connections) should emerge. It is important to note that the vast majority of program managers will not exhibit this behavior, but it is important for the analyst to be cognizant of it nonetheless. Given their scarcity, and the ease with which they are identified (not to mention the ease with which a program manager can choose to avoid them) these intentional biases are mentioned merely for completeness' sake.

It may be mistakenly assumed that, because an individual is a program manager in a particular subject area, or he or she has significant program management experience, that he or she is perfectly capable of making rational decisions without biases. Even without intentional biases to account for, all human beings have unintentional cognitive biases that affect their decision making. These cognitive biases include behaviors such as the availability heuristic, conjunction fallacy, representativeness heuristic, and anchoring and adjustment. It is these unintentional biases that operate at the subconscious level, and are thus more difficult to prevent, that are the focus of this paper. The most common biases are discussed at length, including their potential advantages and disadvantages with respect to program management decisions. The paper concludes with some recommendations for program managers.

Biases and Heuristics

Following is a discussion of several unintentional biases and heuristics that can affect program management decisions. They are discussed in terms of their potential benefits and drawbacks. While biases and heuristics may be seen in a negative light, this perspective is not universally true. It will be shown in this paper that several of these techniques can help a program manager make sound, effective decisions with minimal cognitive effort. The key is for the program manager to recognize when these are being utilized and reject the use of them when it may be harmful in the program management process.

Availability Heuristic

The availability heuristic refers to the practice of basing probabilistic evidence on an available piece of information in one's own set of experiences (Tversky and Kahneman, 1973; Tversky and Kahneman, 1974).

That is to say, humans estimate the likelihood of an event based on a similar event that they can remember (which is by definition, from a biased and unrepresentative sample). Further, since newer events provide greater saliency in one's mind, they influence an individual's reasoning in larger proportion than older events. Additionally, events with unusual characteristics stand out in one's mind (you don't remember the hundreds of times you went to a given restaurant, but you definitely remember the time you got food poisoning).

Since experienced program managers presumably have a larger experienced sampling of events when compared with inexperienced colleagues, it is likely that their propensity for the availability heuristic will decrease as their experience level increases (thereby rendering their samples as more representative of the entire population). They may, for instance, have a better ability to provide a judgment of a particular research organization based on years of experience with that company. However, a more naïve program manager may be able to provide a better result if he/she has experienced a relevant event recently, whereas a program manager with many years of relevant experience (none of which are recent), may not be as likely to provide useful information. For example, a research organization may have had troubles in the past (and thus be under scrutiny from a more experienced program manager), whereas they may have replaced their CEO and significantly improved their performance in recent years, which catches the attention of a newer program manager, encouraging him/her to fund a project to that particular organization (given his/her unawareness of previous performance issues with the prior CEO).

Further, individuals may be biased based on the retrieval mechanism that is utilized to obtain the memory. Depending on who is asking the question, for example, an individual may consciously or unconsciously block memories. The availability heuristic can be a hindrance to effective program management decisions. In order to combat this problem, program managers, both experienced and inexperienced, should be sure to understand how their experiences bias the data they retrieve about a particular scenario.

Representativeness Heuristic

The representativeness heuristic (Tversky and Kahneman, 1974) refers to the phenomena when individuals assume commonalities between objects and estimate probabilities accordingly. For example, a program manager has estimated the probability that a proposed line of research will succeed (and thus decided whether or not to fund the research based on its value when compared with a predetermined

threshold) based on the assumption that a current line of research is similar to this previous research line, thus, estimating their probability of success to be the same. This determination of similarity between objects is typically performed by comparing their attributes. Individuals compute a running tally of matches versus mismatches and then estimate whether or not the item fits a category based on the total. Once the item is categorized, automatic category-based judgments are made about the member item. Using this type of analysis has its issues. There may, in fact, be a glaring difference between the two lines of research that the program manager is overlooking. Similarity (in terms of research organization, budget, duration, or research focus) does not imply a similar probability of success. The new line of research may have subtleties inherent in it that make it significantly riskier. Or, it may be able to leverage the results of the earlier research, thus decreasing the inherent risk.

Additionally, program managers must be careful with category associations as they can be irrational, stereotypical or morally troublesome (e.g., when comparing researchers at the individual level). They may subconsciously influence their actions towards and attitude about the underlying group members.

To combat this bias, individuals must use base rates to compare the underlying category probability versus the specific scenario (e.g., what is the probability that *any* new research program will succeed, given similar circumstances). Then, the base rate can be adjusted to accurately reflect the specific scenario's characteristics.

It should be noted that availability and representativeness are often confused, but they are not the same phenomenon. With availability, individual instances are retrieved and a judgment concerning the frequency of the item is made based on the item's saliency and ease of information retrieval. Alternatively, representativeness involves retrieving information about generic concepts and then a similarity match is made between the item in question and a proposed category. The category association, along with goodness-of-match or degree of similarity produces confidence or a frequency estimate.

Conjunction Fallacy

Another bias that program managers may be prone to is the conjunction fallacy. Tversky and Kahneman (1983) introduce this phenomenon with the following example: Linda is 31, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in antinuclear demonstrations. Is she more likely to be (a) a bank teller, or (b) a bank teller and active in the feminist movement?

The overwhelming majority of those survey respondents answered b, despite the fact that b is more restrictive (and therefore less probable) than a. People report the more complicated scenario as being "more real" or that it "made more sense." A corollary for program managers could be the following: Company A is a large, private industry R&D enterprise. It has been profitable as one of the top 100 R&D enterprises in terms of total expenditures for 50 years, and has NASA, Kellogg and Ford among its previous clients. Is Company A more likely to be (a) successful on its next research project or (b) successful on its next research project and profitable for the upcoming year? Program managers may be inclined to choose b, given the 50 year history of success for the organization. Fundamentally, however, this cannot be the case, as the axioms of probability prevent the combination of two events from being more probable than either of the two individual events.

The conjunction fallacy is counteracted by analyzing individual event probabilities and then combining them. Individuals often make this mistake and it is possible program managers can be prone to this type of fallacy as well. Program managers should not be fooled into thinking that success or failure of an organization or a particular project is more or less likely than is allowed per the laws of probability. This will force program managers to be realistic about their assessments and projections.

Anchoring and Adjustment

Another bias is the anchoring and adjustment heuristic, observed by Tversky and Kahneman (1973). Humans establish anchors as starting points for their judgments and base subsequent observations on the initial value that was provided to them. In other words, if the program manager is provided a baseline value, he/she can be influenced to a degree where subsequent values will be anchored by the provided baseline value. Further, values provided early in the estimation process have a larger weight than those provided late in the process. Additionally, anchors tend to bias information that is sought and included in one's analysis. The status quo is a powerful anchor as well. It is often easier for individuals to take an existing value and adjust it to their specifications. For example, a program manager estimates how long it will take a project to be completed based on previous projects.

The anchoring and adjustment effect can be either beneficial or detrimental. For example, an organization

that is seeking funding may ask for $1 million in seed funding for a project. This initial anchor will bias the program manager's funding decision. If he/she decides to fund the project (and subsequently determines a funding dollar amount), then their funding award will be closely tied to the anchor provided by the research organization. Thus, their award will likely be near $1 million. If the perceived value of the project is well below $1 million, the program manager has been anchored by the research organization's budget and the sponsor has overpaid. If the perceived value of the project is above $1 million, the program manager, similarly anchored to the proposed budget, will underpay based on the aggressive budgeting of the research organization, albeit unintentionally.

Program managers can combat this effect by independently generating funding allocations (or other required estimates) before examining the budget of a proposed project. Then, they can hedge their bets by evaluating the budget proposals from the research organizations and make decisions strategically. Returning to the project example, if the same project with a budget of $1 million is proposed, but the funding organization was prepared to provide $2 million in funding (based on an independent analysis of the project's worth), they will be relieved to find that the researching organization is perceived to be $1 million under the allowable budget. Thus, they will award $1 million and be pleased that they are "getting a bargain." However, if the funding organization is prepared to provide $2 million for the research and the researching organization is asking for $3 million, the sponsor will offer $2 million and take their chances that the researching organization will accept their offer. They will ascertain that the researching organization is seeking too high a level of funding. By independently generating their budget estimates, free of the research organization's anchors, the program managers resist overpaying for R&D.

Recognition Heuristic

The recognition heuristic refers to the heuristic by which an individual selects an alternative that is the most familiar to them. While it seems to be a fundamentally unsound approach to decision making, Goldstein & Gigerenzer (1999) discovered experimentally that this approach often outperforms more rigorous approaches to decision making. It can be useful for "on the fly" decision making in inconsequential scenarios such as deciding on a restaurant while on a road trip based on restaurants you recognize (e.g. McDonald's or Subway) or buying a pair of shoes based on brands that you've worn in the past and know to be reliable (e.g. Nike). With a scenario such as sponsor funding decisions, this heuristic would seem to have no place. After all, funding decisions should be made based on a more rigorous approach than the recognition of an organization by a participating program manager. However, this approach can be useful if only to recognize which researchers have a negative reputation in preceding interactions with them. For example, a sponsor may remember a research organization negatively based on previous poor performance by that organization. This can be a useful heuristic in this case, as a quick decision aid to weed out inferior research organizations. It can only be dangerous, however, if a sponsor uses it as a basis for picking organizations based on recognition of previous performance. This can lead to crowding-out effects, as sponsors begin to award funding to the same researchers on a continuous basis and new researchers have trouble obtaining funding. The negative and positive implementations of this bias must be carefully weighed by program managers.

Duration Neglect

Duration neglect is another bias that may affect sponsors. Typically individuals only view historic experiences with reference to the peak and the end state. If research organization A took 2 years to complete a project and charged $1.5M and research organization B took 4 years to complete a similar project and charged $1M, the more positive memory will be the latter scenario. Individuals typically will remember the cost savings and not the time difference. This influences program managers as well since certain factors will influence them in different manners. Thus, it is important that sponsors take all factors into account when making program management related decisions. This will prevent them from unconsciously biasing one factor over another. The corollary to this is a conscious desire of the program manager to choose the lowest cost research organization or the research proposal with the shortest time horizon.

Diversification Bias

Diversification bias is another bias that can influence program managers in the R&D process. Individuals like to think that they value research portfolio diversity, but over time, when faced with the same choice multiple times, they often make the same choice, thus, tending to regress towards the mean. If a program manager was asked to provide a research portfolio for their organization for the next three years, they will likely diversify the projected portfolio. In reality, when the time comes to make funding decisions, the program manager's decisions will more closely mirror those of historical portfolios rather than reflecting the projected diversity of earlier predictions. This is due in part to the aforementioned biases and heuristics, which

may lead a program manager to maintain funding to particular research organizations on a routine basis rather than try funding a new organization. Once again, as long as this action is performed consciously, there is no issue. It is when the program manager is acting without knowing what he/she is doing that a problem may occur.

Akin to the diversification bias is the hot hand fallacy. In the hot hand fallacy, individuals attribute a pattern to a random streak of positive (or negative) performance. Thus, a research organization may have successfully over-delivered on several recent projects in a row, thereby securing the goodwill of a sponsor in obtaining follow-on funding. This goodwill may be ill-fated, however, as the research organization is slated to regress at some point, not as a byproduct of their incompetence or error, but as a result of the inherent randomness in human performance. For this reason, sponsors would do well to diversify their R&D investments in order to ensure a varied research portfolio (and to prevent the over-achievers from all regressing to the mean at the same time, thereby crippling the organization's research portfolio).

Conclusions

R&D program managers continuously face difficult programmatic decisions. In order to deal with the corresponding overabundance of information, they must rely on biases and heuristics to make decisions in an efficient manner. These biases and heuristics can be exhibited in both an intentional and an unintentional manner. While intentional biases are readily identified, unintentional biases and heuristics require cognizance on the behalf of the program manager. This paper explored several biases and heuristics and discussed their relevance to an R&D program management setting. The key is for the program manager to recognize when these biases are being utilized and reject the use of them when it may be harmful in the program management process. The authors believe the problem explored by this paper necessitates a methodological approach to be developed as future work in support of programmatic decision making.

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