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Behavior in operations management: Assessing recent findings and revisiting old assumptions

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Abstract

In this paper, we provide a perspective on why behavioral research is critical to the operations management (OM) field, what prior research exists, and what opportunities lie ahead. The use of human experiments in operations management is still fairly novel despite a small stream of publications going back more than 20 years. We develop a framework for identifying the types of behavioral assumptions typically made in analytical OM models. We then use this framework to organize the results of prior behavioral research and identify future research opportunities. Our study of prior research is based on a search of papers published between 1985 and 2005 in six targeted journals including the *Journal of Operations Management*, *Manufacturing and Service Operations Management*, *Production and Operations Management*, *Management Science*, *Decision Sciences*, and the *Journal of Applied Psychology.*

Keywords: Behavioral issues; Experimental operations; Human experiments

1. Introduction

Most introductory operations management (OM) courses cover a wide range of topics including product development, process design and improvement, inventory management, forecasting, and supply chain management. Many of the latest tools and techniques taught in such courses are fairly simple and easy to apply. Despite this, there is often a disconnection between the concepts introduced in class and the actual rules-of-thumb followed in practice. There are many reasons for this gap, but most have to do with either a lack of awareness on the part of the OM decision maker or a lack of applicability of the tools themselves. Many of our techniques and theories ignore important characteristics of real systems and therefore are perceived to be difficult to apply in practice. Also, even when methods are known and do apply, they may be difficult to implement given lack of information, trust, or proper incentives.

A common factor in this breakdown is people. When it comes to implementation, the success of operations management tools and techniques, and the accuracy of its theories, relies heavily on our understanding of human behavior. Lack of trust between supply chain partners, incentive misalignment, and natural risk aversion are but three behavioral issues that can negatively impact operational success. The impact of

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behavioral issues on economic activity is studied extensively in many fields, including economics, accounting, marketing, and management. However, its study in operations management is relatively scarce.

Our goal here is to make the case for the importance of behavioral research in the field of operations management. Specifically, we hope to provide inspiration and guidance to other researchers interested in studying behavioral operations management. We do this by first offering a framework for thinking about the behavioral assumptions commonly used in operational models. We divide these assumptions into three categories: Intentions, Actions, and Reactions. This framework allows us to systematically question underlying OM model assumptions and their implications on performance. We believe this characterization is helpful for identifying the types of operational problems that could benefit from behavioral research.

Next we report on the findings of a literature review of papers that investigate behavioral issues in OM. We limited our coverage to papers using human experiments as the methodology for uncovering behavioral effects. We cover papers published between 1985 and June 2005 (i.e., the past 20 years) in six select journals: *Journal of Operations Management*, *Manufacturing and Service Operations Management*, *Production and Operations Management*, *Management Science*, *Decision Sciences*, and the *Journal of Applied Psychology*. The first four journals were chosen since they are arguably the top four journals in the OM field. The remaining two were selected for their broader scope and amenability to experimental research. While relevant papers obviously exist outside this set of journals, we believe this coverage provides a sound initial investigation into the type of research that exists in this area.

Our literature review reveals several interesting findings. First, the application of human experiments to operational problems spans many sub-disciplines including production control, supply chain management, quality management, and operations technology. It appears that behavioral issues arise in a wide range of settings. Second, the number of human experiments using OM-contexts is significantly higher in interdisciplinary journals (such as *Management Science* and *Decision Sciences*) than in journals focused exclusively on OM. Third, the rate of publication over the past 20 years has been relatively stable regardless of recent acknowledgements concerning the importance of incorporating behavioral issues into OM work (e.g., Boudreau et al., 2003). Based on patterns and gaps observed in prior literature, we offer our thoughts on areas within OM that are ripe for further behavioral exploration. We also discuss how one can apply our behavioral assumption framework to different OM problem domains to generate possible research questions.

The paper continues in Section 2 with a brief discussion of the benefits of using behavioral experiments to test issues relevant to OM. In Section 3, we discuss the nature of behavioral assumptions made implicitly or explicitly in OM models and introduce our three assumption categories. This assumption framework is used to organize the main literature review in Section 4. We conclude in Section 5 with a discussion of possible paths for future research.

2. Benefits of behavioral experiments

Behavioral experiments are a well-established research methodology for studying human factor issues in many disciplines including economics, psychology, sociology, and medical research. They are also commonly used in many business disciplines, such as marketing, accounting, and human resources. Their purpose, according to Wacker and John (1998), is "to investigate relationships by manipulating controlled treatments to determine the exact effect on specific dependent variables." Experiments are normally run in carefully controlled settings where specific situational conditions are manipulated by the researcher. The ability to control and modify situational factors allows one to focus attention on the behavioral issue of interest, free of exogenous influences. If carried out effectively, behavioral experimentation provides a way to create conditions where natural behavior can be observed without a loss of generalization.

To appreciate the power and limitations of human experiments, it is important to understand their paradigm assumptions and how these differ from those of more traditional math modeling methodologies. The paradigm assumption of experimental work is that the theory being tested applies in real-world situations and to actors outside the laboratory. Behavioral experiments are sometimes criticized for using students in lieu of closer representatives of the population under question. This can be a valid criticism if, for instance, the reactions being tested depend heavily on the individual life experiences of the subjects. However, even if actual workers were used as subjects in those cases, it would still be problematic applying those findings to workers in a different industry, company, country, or region. Well-designed experiments do not test how students, managers, and employees at a specific corporation act in certain contrived situations.

They test whether *representative humans* react in a predictable manner to controlled stimuli. Properly designed experiments are used to test and develop general theories. It is these theories, not the 'specific' experimental scenarios themselves, which are intended for application. If the theory is accurate, then it should hold in the laboratory. If it does hold the theory gains the support of evidence. The problems that arise in applying experimental lessons in the workplace are similar to those found in applying modeling results. Even if the experiment and model are designed well, the inherent assumptions still need to be relaxed with care.

The paradigm assumptions used in traditional OM modeling concern the applicability of the findings to real world as well, but in a markedly different way. For example, it may prove tractable in an analytical model to assume that a demand distribution is known and stable even though this is rarely the case in practice. Socio-technical Systems Theory reminds us that a change in the technology and techniques of work, the way in which work is done, has an effect on social interactions in the workplace. Changing the technical system without attention to the social one can lead to unintended consequences (Huber and Brown, 1991). Nevertheless, the resulting model can still offer important lessons or normative advice despite this abstraction from reality. Since analytical models are usually developed to establish rules of what *should* be done in constructed settings, and not what actually *is* done in real-world settings, they typically operate under the argument that there is less need to test the model results in empirical settings.

In general, the paradigms of behavioral experimentation and mathematical modeling require different trade-offs. Neither is perfect; each requires its own set of assumptions. However, each methodology can make significant contributions in their own right. More importantly, the two methodologies can complement each other with each positing useful directions of inquiry for the other. The application of both methodologies to the same group of questions offers the opportunity to cross check findings from alternate vantage points and reference frames. An experiment to test the effects of buffer size on output, for example, is an effective way of testing some of the conclusions of line design developed from mathematical modeling. Likewise, the development of the mathematical models may suggest to the behavioral researcher that the variability in task times between workers is key in certain situations while average task time is key in others.

The evolution of behavioral studies within the field of experimental economics provides a nice illustration of the power of this methodology. Early experiments in economics focused mainly on validating existing economic theory and developing methods for inferring model inputs (such as constructing indifference curves or other choice model constructs). Growth in experimental work followed closely from the growth and development of game theory, beginning in the 1940s. This was a natural extension since game theory offers predictions of interactive behavior that are clearly established and ripe for experimental validation. The assumption requirements of game theoretic models, including precise rules for the mechanics of economic interactions, individual reactions and information availability, translate well to an experimental setting. Roth (1993) provides a comprehensive overview of the evolution of experimental economics during this early period (1930–1960). Roth describes one of the surprising findings during this period as follows:

> The design of an experiment to test a particular theory often forces the experimenter to focus on specific aspects of the theory other than those which naturally come to the fore in the theoretical literature. The insights gained from designing an experiment are... often of value even apart from the actual conduct of the experiment. Thus, there is an interplay, on many levels, between theory and experiment.

This observation implies that effective experimental research builds off and enhances what is learned through traditional methodologies.

It is important to note that the established economics community did not uniformly embrace the use of human experiments during this early period. However, experimental economics field has seen exponential growth every decade since (Roth, 1995a). Through this evolution, the focus of experiments has expanded to include an emphasis on developing new behavioral theory to explain gaps between established economic theory and experimental results. Croson (2005, private communication) explains this transformation.

> The evolution of economics from theory-driven to experimental to behavioral has been an interesting one. Neoclassical economics assumes perfect rationality (and typically self-interest, although it need not) and uses those assumptions to predict economic behavior. Experiments were introduced to test these predictions in clean environments (environments which met the conditions of the theory's assumptions). Many times the results from the experiments supported the theory, for example,

market experiments' results look surprisingly like theory's predictions. But other times the results from the experiments did not support the theory's predictions.

These surprises created Kuhnian ''anomalies'' that needed to be explained. As described by philosophers of science like Kuhn, when a critical mass of these anomalies develops, researchers begin searching for alternative theories that help to organize the data; both the mass of previously-known results supporting the existing theory and the new anomalies should be explained in one theory. The current move in economics toward behavioral economics is exactly this search. Behavioral economists generalize existing neoclassical economic theory by adding psychological or behavioral regularities, and then hope to show that these more general theories can explain both existing and new results. Note that the search is still ongoing; no one theory has yet been developed that integrate all the observations. But it is certainly an exciting and important direction, and represents a profound reconceptualization of economic theory and economics more generally.

As Croson notes, Kuhn challenges us to rethink the scientific paradigms common in a given field of research. Kuhn sees science developing as a series of jumps and plateaus, with the jumps occurring at points of paradigm shift. In his review of the last 50 years of Management Science, Hopp (2004) speculates that behavioral factors could be the source of our field's next paradigm shift.

3. Categorizing assumptions in OM

Assumptions are the means by which researchers simplify the world, allowing us to generalize and draw conclusions. Logically developed assumptions are the key to ensuring focus, tractability, and ultimately any level of understanding and comparability in research. However, while assumptions are necessary, the scope of experience and interests of the individual researcher often limit the selection of specific assumptions. The hope is always that what is ''assumed away'' is not critical to the research questions under study.

Since most researchers in the OM field may not have a deep knowledge of behavioral theory, it is not surprising that OM model-based research often uses fairly basic behavioral assumptions. Boudreau et al. (2003) identify seven general behavioral assumptions frequently found in operations research models. These include the implicit assumptions that people are (1) not a major factor in the phenomena under study, (2) deterministic in their actions, (3) predictable in their actions, (4) independent of others, (5) not part of the product, (6) emotionless, and (7) observable. We share the view that the examination of behavioral assumptions, either explicit or implicit, is a valuable way to think through the behavioral implications of mathematical models. Since these pitfalls can arise from a number of misspecifications, we find it helpful to organize our analysis by dividing assumptions into three broad categories: Intentions, Actions, and Reactions. This framework is similar to the Analysis of Assumptions framework used by Meredith et al. (1989).

3.1. Intentions

Intentions refer to the accuracy of the model in reflecting the actual goals of the decision makers. For example, in inventory management, a common objective is to minimize the sum of expected holding and stock-out costs. This objective is an assumption about the decision maker's intentions. In reality, the decision maker may not evenly weigh the cost of holding inventory with the cost of stock-outs. For example, he may weigh stock-out costs less since these are more difficult to track, or he may weigh holding cost less since this it less visible to his colleagues in sales. Also, the assumption of risk neutrality (implied by the expected value objective) may deviate from reality. Depending on the environment, the decision maker could easily be either risk seeking or risk averse. Additionally, he may have certain goals that are not monetary in nature. His decision rules may reflect trust, justice or prior relationships with vendors.

Our assumptions about the decision maker's factor weighting and risk attitude are both forms of intention. Other forms include the decision maker's attitude toward fairness (e.g., whether the distribution of risk or benefits factor into his objective), his intent to work toward system versus individual goals, and his altruistic motivation. In some cases, for example in linear programming applications with low variability, the assumptions of intention are easy to define and match to reality. However, in more complex situations where decision makers are influenced by multiple factors with competing objectives, such assumptions are less clear.

Queuing theory is one OM sub-discipline that has applied the results of behavioral theory to develop more realistic Intension assumptions. For example, patience and abandonment have traditionally been modeled in queuing systems as a static characteristic of the

customer (e.g., Riordan, 1962; Brandt and Brandt, 2000). However, there is empirical evidence that patience is often a characteristic of the system state (Taylor, 1994; Leclerc et al., 1995; Hui and Tse, 1996; Carmon and Hanneman, 1988). This relationship has been explored in the behavioral literature by Maister (1985), Levine (1997), Thieery (1994), Zakay and Hornik (1996), and others. Zohar et al. (2002) have incorporated customer patience based on expectations and anticipated waiting times into a queuing model and explored the equilibrium conditions. In this queuing context, model-generated theory inspired the need for experimental validation, which in turn developed more accurate intention related assumptions for use in subsequent models.

Key questions behavioral researchers can use to identify Intention assumptions in need of validation include: Are the assumptions concerning the goals of the decision maker valid? Are the goals of the decision maker in line with the goals of the company? Does the gap between what the goals of decision makers should be and what they actually are make a difference to the model and model recommendations?

3.2. Actions

Actions refer to the rules or implied behavior of human players in the model. Most of the assumptions discussed by Boudreau et al. (2003) fall into this category. Action assumptions are inherently problem specific. For example, in the supply chain contracting literature, one commonly assumes that supply chain partners will engage in a new contract structure as long as everyone gains. Such a contract is known as being Pareto improving. However, there is some empirical evidence that this does not always hold true. In a survey of food manufacturers engaged in Vendor Managed Inventory, researchers found that those who showed the most benefits from the program were also the most dissatisfied. The reason for this response was that these manufacturers felt their own benefits were much lower than those of their retail partners (Corsten and Kumar, 2005).

Another example in inventory management is the common assumption that stock-out costs are either linear or convex. One possible hypothesis is that stock-out costs are linear with quantity when customers each represent a small fraction of overall sales (e.g., in a retail setting), but convex when customers are more limited in number and order larger quantities more typical of business to business settings. However, this hypothesis has never been tested to our knowledge.

Another Action assumption that permeates much of the OM modeling literature is the idea that individual differences can either be ignored or captured through well-defined probability distributions. The prediction and description of individual differences has always been an important topic in Organizational Behavior (e.g., Hunter et al., 1990; Vinchur et al., 1998; Switzer and Roth, 1998). Models have been developed in the areas of job design (e.g., Wong and Campion, 1991) and socio-technical systems (e.g., Bendoly et al., in press; Huber and Brown, 1991) that specifically address the human factors of work systems, and how variation in performance interacts with the task itself. However, except for the recognition that individual differences are a major cause of work-rate variability (Dudley, 1968; Knott and Sury, 1987; Salvendy and Stewart, 1975; Juran and Schruben, 2004), little has traditionally been done to incorporate individual differences into OM research. This has changed recently with the work of Bartholdi and Eisenstein (2005), Doerr et al. (2000), and Zavadlav et al. (1996). Optimal policies are now known for exploiting worker differences over time in order to optimize departmental performance (Fernandez-Gaucherand et al., 1995). Also descriptive empirical work exists that investigates the magnitude of individual differences in work-rate variability (Doerr and Arreola-Risa, 2000; Schultz et al., 2005) and the consequence of individual differences in work rates and work-rate variability on flow line performance (Doerr et al., 2004).[1]

In general, forms of Actions include a wide range of individual attributes, such as the human players' work rates, cognitive limitations, motivation, ability to process feedback, communication methods, and personal attributes (e.g., cultural or gender influences). The nature of these attributes may shift over time, making them difficult to capture in some cases. Key questions for behavioral researchers include: Do humans (even in extreme cases) act the way they are modeled? If not, is the difference systemic and predictable, and does it affect model recommendations?

3.3. Reactions

Reactions refer to the human players' response to model parameter changes (e.g., situational changes driven by management rules and decisions). Many of the more surprising and interesting insights provided by analytical models deal with Reactions. Here, Reactions

[1] We thank Kenneth Doerr for providing this example.

are captured by the mathematical relationship between parameters and associated insights are developed using sensitivity analysis, comparative static techniques, or numerical experiments. The assumption that people do *not* react to changes going on around them is often embedded in this analytical approach.

Reaction assumptions related to behavior are often less explicit than those concerning Actions or Intentions. For example, in product development, one may be interested in the performance of a project management tool under different project environments. Here, environmental parameters might include the number of tasks and associated resources required, a mapping between tasks and resource needs, the time required for each task (in terms of a distribution), the probability of success for each task, etc. One could easily test reactions to changes in these parameters through an experimental design covering the appropriate parameter ranges. However, the results of this exercise are limited by the possible omission of interactive effects between parameters. For example, one might question whether the probability of task failure should really be treated as a model parameter. In reality, task failure is likely impacted by the dynamics of the project. For example, when a project is *observably* running late people may feel pressure to rush or work long hours, which may alter the probability of task failure.

One behavioral Reaction assumption that has been explored in the OM literature concerns the role of feedback and its impact on human behavior. Behavioral researchers have studied this issue since Weiner in 1954. Feedback has been linked to human motivation in many ways (e.g., Bachrach et al., 2001; Kluger and DeNisi, 1996; Nadler, 1979; Sasone, 1986). Sewell and Wilkinson (1992) noted that low inventory workplaces increase feedback relative to worker pace. The OM literature normally assumes that work pace is independent of buffer size. However, Schultz et al. (1999) show how the feedback from small buffers can affect worker speed. Powell and Schultz (2004) take this a step further by incorporating the idea of inventory-dependent worker speed and examine some of the traditional findings on the design of serial lines.

Reaction assumptions help manage model tractability by limiting the number of interactive factors that must be included. As already stated, the art of any research approach lies in separating critical interactions, that must be considered, from less critical ones. From a behavioral perspective, Reaction assumptions may include implied rules for how decision makers learn, process feedback, game perceived system changes, or are influenced by environmental factors. For behavioral researchers the key questions are: Have behavioral reactions to parameter changes been considered? Are these reactions systemic, predictable, and do they affect model recommendations?

3.4. Additional examples

To further illustrate how this Intention–Action–Reaction categorization maps onto typical OM modeling assumptions, we applied this framework to six different task contexts. The contexts include product development, inventory and DC management, quality management, production and workflow management, procurement and strategic sourcing, and supply chain management. Table 1 offers a summary. Looking down the columns for each assumption category provides a view of the range of problems impacted by each assumption type.

For each OM-context band, the first row lists example assumptions for the three assumption categories. The second row then describes a possible gap between the assumption and actual human behavior. For example, in the procurement and strategic sourcing context, a typical intention assumption is that the decision maker wishes to develop contract terms to minimize contracting cost. This assumption may not hold in situations where trust is critical and can only be gained through first-hand experience. Similarly, a typical Action assumption is that the procurement decision maker is objective, when in reality prior experience may significantly bias choice behavior. Finally, a common Reaction assumption is that parties are results oriented and indifferent to allocation method. However, the procedural justice literature suggests that in some cases the method is as important as the result.

The quality management context offers another view of possible gaps between assumptions and actual human behavior. A typical intention assumption in this case is that one ranks possible improvement efforts by their impact on reducing system variability. However, in industry environments projects may be driven by individual prejudices based on how the individual anticipants the improvement will impact his own future work activities. From an Action perspective, models often recommend random sampling even though human beings are notoriously bad at being intentionally random. Finally, a common Reaction assumption is that the results of a process improvement project are isolated when in reality new procedures often disrupt other system dynamics.

It is evident from this discussion, and the summary provided in Table 1, that behavioral gaps in Intention,

Table 1
Model assumptions and possible behavioral gaps

OM context (task examples)	Assumption categories		
	Intentions	Actions	Reactions
Product development (*resource allocation and sequencing*)			
Common modeling assumptions:	Minimize total project lateness	Trained workers are equal	Task times are sequence independent
Possible behavioral gaps or implications:	Quality as important as lateness	Worker differences increase task variability	Learning and motivation affected by task order
Inventory and DC management (*inventory quantity and location*; *timing of replenishment*)			
Common modeling assumptions:	Minimize the sum of holding and stock-out costs	Assume optimal order rules are followed	Unmet demand is backlogged
Possible behavioral gaps or implications:	May not weight these two costs equally	Not followed due to bounded rationality	Backordering may be dependent on length of wait
Quality management (*sampling*, *safeguarding*, *and corrective policies*)			
Common modeling assumptions:	Minimize product or system variation	Samples are taken randomly	Solutions are isolated
Possible behavioral gaps or implications:	Project choice affected by individual prejudices	Humans are not good randomizers	New procedures disrupt other system dynamics
Production and workflow management (*work allocation*, *capacity levels*, *and control mechanisms*)			
Common modeling assumptions:	Minimize infinite horizon costs	Task times are stationary	Layout designs are work-rate static
Possible behavioral gaps or implications:	Work environment encourages short term view	Task times dependent on environmental factors, such as buffer status	Production layout affects learning rates
Procurement and strategic sourcing (*supplier selection and allocation*, *contract terms*)			
Common modeling assumptions:	Minimize contracting costs	Supplier choice is rational	Supplier relationships are static
Possible behavioral gaps or implications:	Ignores value of earned trust	Prior relationships bias choice behavior	Allocation method affects relationships dynamically
Supply chain management (*collaborative forecasting and planning, multi-party coordination*)			
Common modeling assumptions:	Reduce supply chain average costs	Savings splits will not impact actions if everyone ''gains''	Locus of control is immaterial
Possible behavioral gaps or implications:	May underweight downside risk aversion	Ignores impact of perceived fairness on behavior	Adversity to loss of control

Action, and Reaction assumptions naturally arise in many operational contexts. We now turn to using this assumption framework to organize prior literature and generate ideas for future behavioral research.

4. Literature review

As previously stated, our literature review covers behavioral research published from 1985 to June 2005 that uses human experiments to test or generate an OM theory. Our search uncovered 52 papers of this nature in the following six journals: *Production and Operations Management* (POM), *Journal of Operations Management* (JOM), *Manufacturing and Service Operations Management* (MSOM), *Management Science* (MS), *Decision Sciences* (DS), and the *Journal of Applied Psychology* (JAP). Most of the articles were found in MS, DS, and JAP. Only six studies appeared in POM

and JOM while none appeared in MSOM. There was no major trend in the timing of publications expect that a relatively smaller number appeared in the 1985–1989 time frame.

A citation analysis using the Social Science Citation Index revealed 1108 citations of the 52 papers, not including self-citations by authors. The median number of citations per article was 13. Accounting for the fact that older articles are more likely on average to have larger citation counts than more recent ones, we also calculated the number of citations per number of years out for each article. The average number of citations per year out was 2.4 (standard deviation of 2.2) with a median of 1.9. In terms of where these papers were cited, only 12% of the citations come from journals focused exclusively on OM-specific research.[2] The majority of citations (58%) are made by journals of other business disciplines, such as management, marketing, and management information systems, where experimental research is more developed.[3] Multi-disciplinary journals, such as DS, MS, and JAP, are the source of another 11% of citations. The remaining 19% came from journals outside the mainstream management readership (e.g., *Journal of Creative Behavior* and *Journal of Nursing*).

There are many possible reasons for this allocation of coverage. First, regardless of the growth in empirical methods in operations over the last two decades, the vast majority of papers published in OM-focused journal are still analytical in nature. Secondly, from a sample bias perspective, most articles were printed in multi-disciplinary journals with many authored by researchers outside the OM field. Therefore, some of these papers may not be well known to those in the OM area, even those OM researchers interested in experimental work. Finally, different citation cultures exist among journals, with journals focused on mathematical models tending to contain fewer citations. Regardless of these reasons, the number of overall citations suggests that experimental studies in OM have made a notable impression in well-respected research outlets.

Table 2 provides a breakdown of the articles reviewed and their categorizations in our Intention–Action–Reaction framework. Note that some papers appear in more than one category. By far the greatest percentage of papers (62%) focused on the Action dimension of our framework. In comparison, only 18% and 20% of all articles fell under the Intention and Reaction categories, respectively. The percentage of average citations per article (divided by years in press) is considerably more level across the three categories (see Fig. 1). Below we provide a summary of the major contributions of these papers within each OM-subfield.

4.1. Product development

Product development research in the Intentions category considers how one might structure reward systems to encourage risk taking and effective interdependent outcomes in product development projects. Chow and Haddad (1991) find that relative performance evaluation, where a manager's performance is rated with respect to a peer group, offers some benefits relative to standards-based evaluation. In particular, they find that subjects engaged in R&D project selection exhibited higher project-specified risk and higher overall return, when operating under a relative performance evaluation scheme. This choice of higher risk exposure did not vary significantly with the level of environmental uncertainty (measured in terms of the level of variance in operating income for each project). In contrast, subjects with standards-based incentives chose significantly less risky investments overall and further reduced their risk exposure as environmental uncertainty increased. Mitchell and Silver (1990) investigated whether group or individual goals were more effective incentives within the context of a product creation task that requires worker interdependence. They found that individual goals resulted in worse performance compared with group goals, although this result was highly dependent on the way the individual goals were constructed and their potential to facilitate system level outcomes.

The majority of research within the Action category looks at the decision process associated with whether or not to continue funding a product development project. Garland (1990) examines the impact of the percent of total investment initially committed in a project on the likelihood of allocating additional money (i.e., continuing the project). The study finds that subjects' willingness to authorize additional resources for a threatened R&D project is positively and linearly related to the proportion of the budget already invested. This is commonly known in the behavioral literature as the ''escalation tendency'' or ''sunk cost effect''.

[2] These journals include JOM, POM, and MSOM, as well as *IIE Transactions*, *Operations Research*, *European Journal of Operational Research*, *International Journal of Operations and Production Management*, *Interfaces*, *Naval Research Logistics*.

[3] These journals include *Academy of Management Journal*, *Strategic Management Journal*, *Administrative Science Quarterly*, *MIS Quarterly*, *Information Systems Journal*, *Journal of Consumer Research*, and *Journal of Marketing Research*.

Table 2
Distribution of papers by problem area and behavioral assumption type

OM context	Type of assumption examined		
	Intentions	Actions	Reactions
Product development	Chow and Haddad (1991), Mitchell and Silver (1990)	Basadur et al. (1986), Chow and Haddad (1991), Garland (1990), Garland et al. (1990), Schmidt et al. (2001), Sengupta and Abdel-Hamid (1993), Whyte (1991)	Connolly and Dean (1997), Sengupta and Abdel-Hamid (1993)
Inventory and DC management	Kernan and Lord (1990), Schweitzer and Cachon (2000)	Kernan and Lord (1990), Moxnes (1998), Robinson and Swink (1995), Smelcer and Carmel (1997), Swink (1995), Swink and Robinson (1997), Swink and Speier (1999)	Kernan and Lord (1990), Swink (1995), Swink and Robinson (1997), Schweitzer and Cachon (2000)
Quality management and control	Gully et al. (2002), Soman and Shi (2003)	Ghosh and Ray (1997), Larson and Callahan (1990), Pei and Reneau (1990), Robinson and Robinson (1994), Stanton and Barnes-Farrell (1996)	Larson and Callahan (1990), Stanton and Barnes-Farrell (1996)
Production and workflow management	Audia et al. (1996), Johnson et al. (2002), Stading et al. (2001)	Aiello and Kolb (1995), Anson et al. (1995), Bachrach et al. (2001), Baily (1989), Bretz and Thompsett (1992), Doerr et al. (1996), Hirst (1988), Johnson et al. (2002), Lawrence et al. (1986), Robinson and Robinson (1994), Schultz et al. (1998, 1999, 2003), Sharda et al. (1988)	Doerr et al. (1996, 2004), Schultz et al. (1998, 1999, 2003)
Procurement and strategic sourcing	Gelfand and Realo (1999)	Bolton et al. (2004), Katok and Roth (2004), Sarin and Weber (1993)	Kwasnica et al. (2005)
Supply chain management	Gupta (1989), Steckel (1990)	Bolton et al. (2003), Gupta (1989), Steckel (1990), Sterman (1989)	Croson and Donohue (2003), Steckel et al. (2004)

Garland et al. (1990) examine how the level of sunk costs works together with negative feedback to influence decisions. This is explored in the context of oil drilling, with sunk costs represented by the number of dry wells already drilled. They find in this context that the higher the sunk cost, the less likely a subject is to continue the venture. This is counter to the classic sunk cost effect. Whyte (1991) finds that the inclusion of a group (versus one person) in decisions concerning initial investments in a project can also reduce the sunk cost effect by diffusing the responsibility for a seemingly poorly performing project. Similarly, Schmidt et al. (2001) find that group versus individual decision making in later stages of a project also reduce this effect. Interestingly, they also find that virtual teams (connected electronically) make more effective decisions than face-to-face teams. Other Action related work includes Basadur et al. (1986) who test the impact of training on manufacturing engineers' ability to engage in divergent thinking when solving product development problems.

Reaction related research in product development looks at how to support difficult decisions using appropriate feedback or task structure. Sengupta and Abdel-Hamid (1993) examine this question in the context of a set of simulated software development

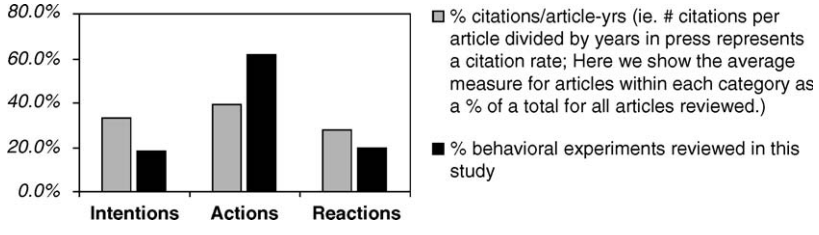

Fig. 1. Breakdown of papers and citations by assumption type.

projects. Subjects, in the role of project managers, were asked to make a series of staffing decisions over a project's life. They found that subjects given cognitive feedback performed the best, followed by those given cognitive feed-forward information. Those given only outcome-based feedback performed the worst. Connolly and Dean (1997) test the ability of decision makers to predict the time required to complete a software project requiring individual and group tasks. They find that subjects are consistently too tight in their estimations, with over half of actual outcomes falling in the 1% tail of estimated distributions. They also find that requiring subjects to estimate extreme upper and lower time limits significantly improved their forecasting ability.

4.2. Inventory and DC management

Within the Intentions category, Kernan and Lord (1990) design an experiment involving a simple inventory audit task to test the influence of different motivational factors when workers are rewarded by either single or multiple goals. This operational setting allows them to extend prior behavioral research on motivation to a repeated game environment where they can examine the influence of feedback, learning, and goal adjustments. Schweitzer and Cachon (2000) examine decision making in the classic newsvendor problem under different cost parameters. They find that human decision makers consistently deviate from the profit maximizing order quantity. They also find that this deviation is not well explained by alternative objective functions based on risk-aversion, risk-seeking, Prospect Theory preference, or stock-out aversion (among others). However, the ordering pattern is consistent with a "preference to reduce ex-post inventory error" and with a new heuristic they develop called "the anchoring and insufficient adjustment heuristic."

Within the Actions category, Moxnes (1998) investigates an interesting stock resource management problem where the stock (cod fish) is a renewable resource. He notes that two problems may lead to over-investment. The first is the "commons problem" which occurs because the benefits of investment accrue to the individual while renewable resource costs are borne by all. The second is a provisioning problem that may happen when the problem itself is so complex that misperceptions of the problem dynamics lead to poor solution heuristics. The experiment controls for the "commons problem" in order to focus exclusively on misperception influences. The results show that investors have a tendency to discount feedback delays and misperceive the dynamics of stocks and flows. Several interesting parallels are drawn between these causes and the misperception causes contributing to the bullwhip phenomenon (e.g., Sterman, 1989).

The remaining papers within the Action category examine how individuals process information provided by decision support systems (DSS). Swink (1995) is one of the first papers to study the potential performance benefits of using a DSS for making logistics decisions. They find that user characteristics, such as intuition and effort increase solution performance in this context, while preference for disaggregated data tends to reduce performance. Robinson and Swink (1995) study alternative methodologies for solving logistics problems, ranging from intuition, scenario evaluation, heuristic, and optimization procedures. Swink and Robinson (1997) examine the relative solution performance of four different scenario-based DSS, also in a logistics context. They find that having incremental cost improvement cues significantly improved performance. Smelcer and Carmel (1997) consider differences in ability to process graphical versus tabular representation of data in a variety of problem solving contexts. While they do not discuss an OM-problem per say, the behavioral issue they examine is relevant to network design problems. The factors they consider include level of task difficulty, individual cognitive differences (in style and skills), and the type of geographic relationships that can be represented. Swink and Speier (1999) examine the impact of geographic data representation in a logistics decision context, where subjects are asked to make network decision choices. They test the effectiveness of geographic representation on performance under different levels of data aggregation, problem size, degree of data dispersion, and subjects' spatial orientation skills. They find that these characteristics have several interesting interaction effects that significantly impact performance.

The Reaction category is also considered in some of the above papers, and so we refrain from outlining their main insights again here. Most of these papers offer insight into human reactions to feedback or learning over time. For example, Schweitzer and Cachon (2000) find that offering feedback between rounds of the newsvendor game does not help subjects overcome their preference bias. Several recent papers (outside the parameters of our survey) have extended these results to capture the impact of more detailed feedback and learning mechanisms (e.g., Benzion et al., 2005; Bolton and Katok, 2005; Lurie and Swaminathan, 2005).

4.3. Quality management and control

Intention related experiments in quality management focus mainly on settings where the level of control over processes varies over time. Gully et al. (2002) begin with the acknowledgement that process control is largely an artifact of individuals charged with tasks. They show that personal characteristics can moderate the impact of offering specific instructions designed to either avoid or disregard process error. They further suggest that failing to account for such behavioral moderation threatens the performance of broad-based guidelines for quality improvement. Other work focuses on individual willingness to engage in processes where one is forewarned of inherent control problems. Soman and Shi (2003) outline a set of experiments where individuals choose to engage in one of two processes differing by the level of process control. Their results suggest that higher process control is preferred. However, advanced knowledge that variation in processes will occur at later points in time helps assuage one's aversion to lower process control. This suggests that delaying process variability might help ensure greater buy-in, motivation, and the overall appeal of engagement.

Quality studies where the required Actions of individuals undergo an explicit manipulation have a relatively long, if sparse, history. Robinson and Robinson (1994) discuss a series of tabletop experiments used in the U.S. and Japan in the first half of the 20th century. Although they do not explicitly replicate the experiments in their work, they do provide the first formally documented description of the methods used. The experimental results provide insight into the role of stress and fatigue on error rates, the occasional pitfalls of forced standards, and the potential synergies of work sharing on process flow and quality. Pei and Reneau (1990) study the role of training and decision support on the evaluation of internal process control. Similar to the tabletop experiments, where standard methods were enforced, Pei and Reneau (1990) show that individual assessment of internal control problems is compromised when training is inconsistent with prior knowledge. Ghosh and Ray (1997) examine how individual characteristics impact quality control by studying the role that varying levels of risk have on individual decisions regarding sampling size. They find that individuals with greater tolerance for risk and ambiguity prefer smaller sampling sizes even when risk and ambiguity increase. This has interesting implications for the associated level of Type II error borne by the organization.

Within the Reactions category, Larson and Callahan (1990) examine the influence of management pressure in a setting where individuals are free to manage the timing of multiple tasks. They find that work monitoring, while potentially beneficial to monitored tasks, can have unintended consequences on the quality of non-monitored tasks. Stanton and Barnes-Farrell (1996) show additional reactionary results. Their findings show that, regardless of the potential guidance provided by the monitoring of error identification tasks, individuals with the ability to delay monitoring events actually do better in those tasks. This suggests that care should be taken in implementing monitoring programs to avoid high pressure, stifling, and ultimately counter-productive behavioral phenomena.

4.4. Production and workflow management

Much of the production and workflow management research focuses on themes of feedback, goals, and interdependence of work. For example, Hirst (1988) looks at the effects of intrinsic motivation on Intentions. He finds a tendency for reciprocal interdependence to promote intrinsic motivation and attributes this to task difficulty and variety. Audia et al. (1996) and Doerr et al. (1996) look at the interactions of work processes and goals. Audia et al. (1996) find that goal choices affect individual workers' intentions for task order but goal form has no effect. Doerr et al. (1996) find that task interdependence can lead to poor performance in situations with individual goal settings. They also found equal productivity in situations with unequal buffer capacity and idle time. Schultz et al. (1998, 1999) also explore the reaction of workers to buffer capacity. They look at the common modeling assumption of independence of processing times from buffer contents. The 1998 study shows that, despite significantly higher idle time in a low inventory situation, productivity is unchanged. The 1999 study looks at feedback, goals, and the development of group norms to explain this effect. Doerr et al. (2004) find that work organization affects between and within variability in task times. Feedback is the concern of Aiello and Kolb (1995). They look at the effects of different audiences on worker performance. Available feedback is also found to be an important element of plant performance outcomes in the study by Bachrach et al. (2001). Robinson and Robinson (1994) also look at the effects of task organization on task time by re-examining Gilbreth's tabletop experiments.

Experimental work in production and workflow management is often concerned with the Intentions and

Actions of decision makers. Stading et al. (2001) look at the goals of decision makers when choosing capital investments in equipment and find that strategic infrastructural factors play an important role. Johnson et al. (2002) find that the intentions relative to award allocation in a manufacturing setting are partially based on reputation and attribution of motive. Juran and Schruben (2004) show that variability of human reactions should be considered when modeling production systems.

Three studies we have placed in the Action realm look at the value of including intervention and assistance when making decisions in an operational setting. Lawrence et al. (1986) find that including human judgment forecasts in a mix of forecasting techniques increases accuracy, especially in short run forecasts. Anson et al. (1995) use a production-planning environment to test the effects of facilitators on meetings. They find that human facilitators increased cohesion and improved processes. Sharda et al. (1988) explore the effectiveness of decision support systems in a situation with uncertainty in competitors' actions and economic conditions. They find a definite learning curve and improvements in decision quality and variance. Umanath et al. (1990) experimentally explore the arrangement of information on a computer screen and its effect on recall.

The production and workflow management group also includes two Action papers on learning. Baily (1989) experimentally tests the relationship between forgetting and the learning curve. He finds that forgetting is a function of procedural versus continuous control tasks as well as the amount learned and the passage of time. He does not find support for the assumption that modeling of forgetting can be done by returning to a previous point on the learning curve. Bretz and Thompsett (1992) used training at Kodak to explore different training techniques. Comparing traditional training with Integrative Learning they show an increase in favorable reactions but no change in performance. More recent experimental work associated with feedback, learning, and experience in production and workflow contexts, demonstrates the role of task interdependence on managerial support of both subordinate workers and IT systems (e.g., ERP, Bendoly et al., in press; Bachrach et al., in press). Since supportive leadership can directly impact motivated action and levels of individual productivity (Bendoly and Hur, in press), it is obvious that issues affecting such support need to be considered in process design.

4.5. Procurement and strategic sourcing

There is a long history of work in experimental economics on negotiations and the efficiency of alternative market designs, such as auctions and other bargaining systems. See Roth (1995b) and Kagel (1995) for a review of this literature, most of which is published outside the six journals we surveyed. This literature provides a solid base for identifying behavioral influences in the operation of procurement systems. The five papers identified in our survey help illustrate this point.

Gelfand and Realo (1999) perform an experiment involving buyers and sellers of advertising to test how individualism versus collectivism norms across cultures influence the effects of accountability in negotiations. They find that high accountability enhances competition for subjects with low levels of collectivism, while enhancing cooperation for subjects with high collectivism. Sarin and Weber (1993) test the influence of market design when a procurement transaction involves ambiguity in probability due to lack of information or training. Their experimental results show that in both sealed bid and double oral auctions, subject bids and market prices are consistently lower when probabilities are ambiguous. Katok and Roth (2004) examine the performance of two auction mechanisms, the descending price Dutch auction and eBay's ascending uniform-price Dutch auction, when synergies exist across multi-unit purchases. Such synergies are common in business-to-business environments involving fixed transportation, quality control, or order processing costs. They find that the descending price Dutch auction is more robust to exposure and free-rider problems. Bolton et al. (2004) test the potential benefit of online feedback as a means to overcome moral hazard problems often associated with trade among strangers. Their experiment compares an online market setting with and without feedback, as well as a setting where participants engage face-to-face. They find that online feedback does mitigate moral hazard behavior, but also introduces an interesting public goods problem since the benefits of trustworthy behavior are now enjoyed by the entire community. Finally, Kwasnica et al. (2005) introduce and test the performance of a new auction design coined the Resource Allocation Design (RAD) auction, which combines the best aspects of simultaneous multi-round and adoptive user selection mechanisms. More recent experimental studies in the procurement area (that fall outside our survey parameters) include Bajari et al. (2003), Engelbrecht-Wiggans and Katok (2005), and Engelbrecht-Wiggans et al. (2005).

4.6. Supply chain management

Much of the experimental work in supply chain management focuses on issues related to the bullwhip effect. Croson and Donohue (2002) provide a survey of this research. Simply stated, the bullwhip effect is a phenomenon where orders received at each level of the supply chain increase in variation as one moves further from the final consumer. Sterman (1989) was the first to identify a behavioral cause for this phenomenon. He found that supply chain members tend to discount the magnitude of their outstanding orders when making ordering decisions, which in term causes them to over-react to stock-out or over-stock situations. He refers to this behavioral tendency as supply line underweighting. Croson and Donohue (2003) show that passing point-of-sale (POS) information can lessen, although not eliminate, this behavioral tendency. Steckel et al. (2004) test the impact of both POS data sharing and lead-time reductions under a wide range of demand conditions. More recent research in this area (falling outside our survey parameters) includes Croson and Donohue (in press-a,b), Croson et al. (2005), and Wu and Katok (in press).

The remaining papers in this category focus on bargaining issues that are quite general in nature. Some of these papers do not actually describe a supply chain problem or tailor their results to an OM-context. However, we include them in the survey because the insights they provide could be applied to a supply chain collaboration initiative (such as a collaborative planning, forecasting, and replenishment, or collaborative logistics). For example, Bolton et al. (2003) examine the impact of communication patterns in negotiations in the context of a merger decision between three companies. They find that parties in a weaker position in terms of alternatives benefit from a constrained communication structure where information is not publicly shared with all parties. In contrast, stronger parties prefer open communication since it triggers more competitive bidding. Gupta (1989) studies the existence and influence of reference points (i.e., a middle point agreement on both sides) in collaborative two-party negotiations. They develop a model that shows how bargainers move from this reference point to a point on the players' Pareto boundary that maintain the same balance of power. Experimental results confirm this behavior in some cases. Finally, Steckel (1990) shows that decision makers in a committee setting abide by the Core concept, which implies that an alternative will be chosen if it has a strict simple majority over all other alternatives.

5. Discussion and summary remarks

Our initial discussion of assumption types (in Section 3) outlined a number of behavioral assumptions that one could test in future research. Table 1 also provides specific hypotheses that could be tested in different OM contexts. We conclude with a number of additional ideas and conclusions drawn from the papers listed in Table 2.

The majority of papers surveyed focus on operational decisions within two traditional (and tactical) contexts: inventory management and production management. However, one could argue that behavioral issues are even more likely to arise in the remaining four context areas (namely product development, quality management, procurement and strategic sourcing, and supply chain management). For example, the success of a product development or quality improvement project is inherently riddled with environmental factors that may impact human behavior. Similarly, supply chain management and sourcing tasks involve reliance on multiple parties across different organizations, with different perspectives, capabilities, objectives, and information availability. OM theory concerning institutional structure and interaction effects is beginning to emerge in these areas (thanks to recent applications of empirical methods within OM). We believe these theories could be further tested, refined, and strengthened through carefully designed human experiments.

There has also been an explosion of OM research in the last 10 years focusing on interaction effects among decentralized decision makers. This research combines traditional OM models of scheduling, inventory planning, quality management, supply chain management, etc., with game theoretic rules and analysis indicative of decentralized decision making environments (e.g., see Cachon and Netessine, 2004 for a review). The tight connection between game theory and experimental methods in economics suggests that experiments may be an important tool for testing these new game theoretic results in OM. In future years, we hope to see the body of behavioral work accelerate within these problem domains.

In terms of the types of assumptions tested, Table 2 shows a dominance of work related to Action assumptions. This might be due to the fact that many OM theories relate to the optimal actions (i.e., operations) of individuals or systems. Theories concerning the Intentions or Reactions of individuals are often less developed. In the case of Intentions, it is also perhaps more difficult to identify behavioral insights that are truly novel to OM settings. For example, one might identify the behavioral characteristic that inventory managers are risk averse, but

is this aversion unique to the OM task or simply in line with the aversion exhibited by managers in other business settings? Tests of Action and Reaction assumptions are likely to be more directly associated with OM settings; often capturing specific aspects of task dependencies or second moment phenomenon (e.g., planned variations and/or uncertainty in input, output, or demand). So, while we hope experimental research will continue to test assumptions of all types, we expect the Action category to continue to dominate and the Reaction category to gain momentum.

Another way to categorize prior experimental research is to consider the environment of the experiment itself. The literature we reviewed falls into three types: (1) industrial experiments where real workers are observed performing authentic tasks, (2) laboratory experiments where subjects take part in a controlled, and often stylized, version of an authentic task, and (3) situational experiments where subjects are given a description of a situation and asked to answer questions about how they would feel or act in such a situation. The majority of publications included in Table 2 were of the second type (approximately 75%). Only six papers involved industrial experiments. We hope the number of industrial experiments, in particular, will grow in future years.

In summary, we believe behavioral experiments, if properly designed and executed, can provide windows into a wide range of phenomena of interest to operations managers. We view experimental research as a means for ensuring more realistic OM theories and models, with the assumptions of many established OM theories serving as a vast and rich ground for experimentation. Our assumption framework provides one method for identifying implicit behavioral assumptions in OM models. We look forward to the emergence of other frameworks, as well as updated literature reviews, in the years to come.

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References

Aiello, J.R., Kolb, K.J., 1995. Electronic performance monitoring and social context: impact on productivity and stress. Journal of Applied Psychology 80 (3), 339–353.

Anson, R., Bostrom, R., Wynne, B., 1995. An experiment assessing group support system and facilitator effects on meeting outcomes. Management Science 41 (2), 189–208.

Audia, G., Kristof-Brown, A., Brown, K.G., Locke, E.A., 1996. Relationship of goals and microlevel work processes to performance on a multipath manual task 81 (5) 483–497.

Bachrach, D.G., Bendoly, E., Podsakoff, P.M., 2001. Attributions of the "causes" of group performance as an alternative explanation of the relationship between organizational citizenship behavior and organizational performance. Journal of Applied Psychology 86 (6), 1285–1293.

Bachrach, D.G., Powell, B., Bendoly, E. Organizational citizenship behavior and performance evaluations: exploring the impact of task interdependence. Journal of Applied Psychology, in press.

Baily, C.D., 1989. Forgetting and the learning curve: a laboratory study. Management Science 35 (3), 340–352.

Bajari, P.L., McMillan, R.S., Tadelis S., 2003. Auctions Versus Negotiations in Procurement: An Empirical Analysis, NBER Working Paper 9757.

Bartholdi III, J.J., Eisenstein, D.D., 2005. Using bucket brigades to migrate from craft manufacturing to assembly lines. Manufacturing and Service Operations Management 7 (2), 121–131.

Basadur, M., Graen, G.B., Scandura, T.A., 1986. Training effects on attitudes toward divergent thinking among manufacturing engineers. Journal of Applied Psychology 71 (4), 612–617.

Bendoly, E., Bachrach, D.G., Powell, D. The role of operational interdependence and supervisory experience on management assessments of resource planning systems. Production and Operations Management, in press, doi:10.1016/j.jom.2005.08.004.

Bendoly, E., Hur, D. Bipolarity in reactions to operational 'constraints': OM bugs under an OB lens. Journal of Operations Management, in press.

Benzion, U., Cohen, Y., Peled, R., Shavit, T., 2005. Decision-Making and the Newsvendor Problem—An Experimental Study. Working Paper, Ben-Gurion University.

Bolton, G.E., Chatterjee, K., McGinn, K.L., 2003. How communication links influence coalition bargaining: a laboratory investigation. Management Science 49 (5), 583–598.

Bolton, G.E., Katok, E., Ockenfels, A., 2004. How effective are electronic reputation mechanisms? an experimental investigation. Management Science 50 (11), 1587–1602.

Bolton, G.E., Katok, E., 2005. Learning-by-Doing in the Newsvendor Problem: A Laboratory Investigation of the Role of Experience and Feedback. Working Paper, Penn State University.

Boudreau, J., Hopp, W., McClain, J.O., Thomas, L.J., 2003. On the interface between operations and human resource management. Manufacturing and Service Operations Management 5 (3), 179–202.

Brandt, A., Brandt, M., 2000. Asymptotic Results and a Markovian Approximation for the M(n)/M(n)/s + Gi System. Preprint, SC00-12, Konrad-Suse-Zentrum, Berlin, Germany.

Bretz, R.D., Thompsett, R.E., 1992. Comparing traditional and integrative learning methods in organizational training programs. Journal of Applied Psychology 77 (6), 941–951.

Cachon, G., Netessine, S., 2004. Game theory in supply chain analysis. In: Simchi-Levi, D., Wu, S.D., Shen, Z.J. (Max) (Eds.), Handbook of Quantitative Supply Chain Analysis: Modeling in the eBusiness Era. Kluwer.

Chow, C.W., Haddad, K.M., 1991. Relative performance evaluation and risk taking in delegated investment decisions. Decision Sciences 22 (3), 583–593.

Connolly, T., Dean, D., 1997. Decomposed versus holistic estimates of effort required for software writing tasks. Management Science 43 (7), 1029–1245.

Corsten, D., Kumar, N., 2005. Do Suppliers Benefit from Collaborative Relationships with Large Retailer? An Empirical Investigation of ECR Adoption. Working Paper, University of St. Gallen, Switzerland.

Croson, R., Donohue, K., 2002. Experimental economics in supply-chain management. Interfaces 32 (5), 74–82.

Croson, R., Donohue, K., 2003. Impact of POS data sharing on supply chain management: an experimental study. Production and Operations Management 12 (1), 1–11.

Croson, R., Donohue, K. Behavioral causes of the bullwhip effect and the observed value of inventory information. Management Science, in press-a.

Croson, R., Donohue, K. Upstream versus downstream information and its impact on the bullwhip effect. Systems Dynamics Review, 21(3), in press-b.

Croson, R., Donohue, K., Katok, E., Sterman, J., 2005. Order Stability in Supply Chains: Coordination Risk and the Rule of Coordination Stock. Working Paper, Penn State University.

Doerr, K.H., Arreola-Risa, A., 2000. A worker-based approach for modeling variability in task completion time. IIE Transactions 32 (7), 625–636.

Doerr, K.H., Freed, T., Mitchell, T.R., Schriesheim, C.A., Zhou, X., 2004. Workflow policy and within-worker and between-worker variability in performance. Journal of Applied Psychology 89 (5), 911–921.

Doerr, K.H., Klastorin, T.D., Magazine, M.J., 2000. Synchronous unpaced flow lines with worker differences and overtime cost. Management Science 46 (3), 421–435.

Doerr, K.H., Mitchell, T.R., Klastorin, T.D., Brown, K.A., 1996. Impact of material flow policies and goals on job outcomes. Journal of Applied Psychology 81 (2), 142–152.

Dudley, N.A., 1968. Work Measurement: Some Research Studies. Macmillan, London.

Engelbrecht-Wiggans, R., Katok, E., 2005. e-Sourcing in Procurement: Theory and Behavior in Reverse Auctions with Non-Competitive Contracts. Working Paper, College of Business, University of Illinois, Campaign, IL.

Engelbrecht-Wiggans, R., Haruvy, E., Katok, E., 2005. Market Design for Procurement: Empirical and Theoretical Investigation of Buyer-Determined Multi-Attribute Mechanisms. Working Paper, College of Business, University of Illinois, Campaign, IL.

Fernandez-Gaucherand, E., Jain, S., Lee, H.L., Rao, A.G., Rao, M.R., 1995. Improving productivity by periodic performance evaluation: a Bayesian stochastic model. Management Science 41 (10), 1669–1678.

Garland, H., 1990. Throwing good money after bad: the effect of sunk costs on the decision to escalate commitment to an ongoing project. Journal of Applied Psychology 75 (6).

Garland, H., Sandefur, C.A., Rogers, A.C., 1990. De-escalation of commitment in oil exploration: when sunk costs and negative feedback coincide. Journal of Applied Psychology 75, 721–727.

Gelfand, M.J., Realo, A., 1999. Individualism-collectivism and accountability in intergroup negotiations. Journal of Applied Psychology 84 (5), 721–736.

Ghosh, D., Ray, M.R., 1997. Risk, ambiguity, and decision choice: some additional evidence. Decision Sciences 28 (1), 81–104.

Gully, S.M., Payne, S.C., Koles, K.L.K., Whiteman, J.K., 2002. The impact of error training and individual differences on training outcomes: an attribute–treatment interaction perspective. Journal of Applied Psychology 87 (1), 143–155.

Gupta, S., 1989. Modeling integrative multiple issue bargaining. Management Science 35 (7), 788–806.

Hirst, M.K., 1988. Intrinsic motivation as influenced by task interdependence and goal setting. Journal of Applied Psychology 73 (1), 96–101.

Hopp, W.J., 2004. 50th anniversary article; fifty years of management science. Management Science 50 (1), 1–7.

Huber, V.L., Brown, K.A., 1991. Human resource issues in cellular manufacturing: a socio-technical analysis. Journal of Operations Management 10 (1), 138–159.

Hunter, J.E., Schmidt, F.L., Judiesch, M.K., 1990. Individual differences in output variability as a function of job complexity. Journal of Applied Psychology 75 (1), 28–42.

Hui, M.K., Tse, D.K., 1996. What to tell customers in waits of different lengths: an interactive model of service evaluation. Journal of Marketing 60, 81–90.

Johnson, D.E., Erez, A., Kiker, D.S., Motowidlo, S.J., 2002. Liking and attributions of motives as mediators of the relationships between individuals' reputations, helpful behaviors, and raters' reward decisions. Journal of Applied Psychology 87 (4), 808–815.

Juran, D.C., Schruben, L.W., 2004. Using worker personality and demographic information to improve system performance prediction. Journal of Operations Management 22, 355–367.

Kagel, J., 1995. Auctions: a survey of experimental research. In: Kagel, J., Roth, A. (Eds.), Introduction to Experimental Economics, Handbook of Experimental Economics. Princeton University Press (Chapter 7).

Katok, E., Roth, A.E., 2004. Auctions of homogeneous goods with increasing returns: experimental comparisons of alternative ''Dutch'' auctions. Management Science 50 (8), 1044–1063.

Kernan, M.C., Lord, R.G., 1990. Effects of valence, expectancies and goal-performance discrepancies in single and multiple goal environments. Journal of Applied Psychology 75 (2), 194–203.

Kluger, A.N., DeNisi, A., 1996. The effects of feedback interventions on performance: a historical review, a meta-analysis, and a preliminary feedback intervention theory. Psychological Bulletin 119 (2), 254–284.

Knott, K., Sury, R., 1987. A study of work–time distributions on unpaced tasks. IIE Transactions 19 (3), 50–55.

Kwasnica, A.M., Ledyard, J., Porter, D., DeMartini, C., 2005. A new and improved design for multiobject iterative auctions. Management Science 51 (3), 419–434.

Larson, J.R., Callahan, C., 1990. Performance monitoring: how it affects work productivity. Journal of Applied Psychology 75 (5), 530–538.

Lawrence, M.J., Edmundson, R.H., O'Connor, M.J., 1986. The accuracy of combining judgemental and statistical forecasts. Management Science 32 (12), 1521–1533.

Leclerc, F., Shmitt, B.H., Dube, L., 1995. Waiting time and decision making: is time like money? Journal of Consumer Research 22, 110–119.

Levine, R., 1997. A Geography of Time. Harper Collins Publishers, New York.

Lurie, N.H., Swaminathan, J.M., 2005. Is Timely Information Always Better? The Effect of Feedback Frequency on Performance and Knowledge Acquisition. Working Paper, University of North Carolina.

Maister, D.H., 1985. The psychology of waiting lines. In: Czepiel, J.A. (Ed.), The Service Encounter. Lexington Books, Lexington, MA, pp. 322–331.

Mitchell, T., Silver, W., 1990. Individual and group goals when workers are interdependent: effects on task strategies and performance. Journal of Applied Psychology 75, 185–193.

Moxnes, E., 1998. Not only the tragedy of the commons: misperceptions of bioeconomics. Erling Moxnes. Management Science 44 (9), 1234–1248.

Nadler, D.A., 1979. The effects of feedback on task group behavior: a review of the experimental research. Organizational Behavior and Human Performance 23, 309–338.

Pei, B.K.W., Reneau, J.H., 1990. The effects of memory structure on using rule-based expert systems for training: a framework and an empirical test. Decision Sciences 21 (2), 263–286.

Powell, S.G., Schultz, K.L., 2004. Throughput in serial lines with state-dependent behavior. Management Science 50 (8), 1095–1105.

Riordan, J., 1962. Stochastic Service Systems. Wiley, New York.

Robinson, A.G., Robinson, M.M., 1994. On the tabletop improvement experiments of Japan. Production and Operations Management 3 (3), 201–216.

Robinson, E.P., Swink, M.L., 1995. A comparative model of facility network design methodologies. Journal of Operations Management 13 (3), 169–181.

Roth, A.E., 1993. On the early history of experimental economics. Journal of the History of Economic Thought 15 (Fall), 184–209.

Roth, A.E., 1995a. In: Kagel, J., Roth, A. (Eds.), Introduction to Experimental Economics, Handbook of Experimental Economics. Princeton University Press, (Chapter 1), pp. 3–109.

Roth, A.E., 1995b. Bargaining experiments. In: Kagel, J., Roth, A. (Eds.), Introduction to Experimental Economics, Handbook of Experimental Economics. Princeton University Press (Chapter 4).

Salvendy, G., Stewart, G., 1975. The prediction of operator performance on the basis of performance tests and biological measures. AIIE Transactions 7 (4), 379–387.

Sarin, R.K., Weber, M., 1993. Effects of ambiguity in market experiments. Management Science 39, 602–615.

Sasone, C., 1986. A question of competence: the effects of competence and task feedback on intrinsic interest. Journal of Personality and Social Psychology 51 (5), 918–931.

Schmidt, J.B., Montoya-Weis, M., Massey, A.P., 2001. New product development decision-making effectiveness: comparing individuals, face-to-face teams, and virtual teams. Decision Sciences 32 (4), 575–600.

Schultz, K., Juran, D., Boudreau, J., 1999. The effects of low inventory on the development of productivity norms. Management Science 45 (12), 164–1678.

Schultz, K., Juran, D., Boudreau, J., McClain, J., Thomas, L.J., 1998. Modeling and worker motivation in JIT production systems. Management Science 44 (12), 1595–1607.

Schultz, K.L., McClain, J.O., Thomas, L.J., 2003. Overcoming the dark side of worker flexibility. Journal of Operations Management 21 (1), 81–92.

Schultz, K.L, Schoenherr, T., Nembhard, D., 2005. Equity Theory Effects on Worker Motivation and Speed on an Assembly Line. Working Paper, S.C. Johnson Graduate School of Business.

Schweitzer, M.E., Cachon, G.P., 2000. Decision bias in the newsvendor problem with a known demand distribution: experimental evidence. Management Science 46 (3), 404–420.

Sengupta, K., Abdel-Hamid, T.K., 1993. Alternative conceptions of feedback in dynamic decision environments: an experimental investigation. Management Science 39 (4), 411–428.

Sewell, G., Wilkinson, B., 1992. Someone to watch over me: surveillance, discipline and the just-in-time labour process. Sociology 26 (2), 271–289.

Sharda, R., Barr, S.H., McDonnel, J.C., 1988. Decision support system effectiveness: a review and an empirical test. Management Science 34 (2), 139–159.

Smelcer, J., Carmel, E., 1997. The effectiveness of different representations for managerial problem solving: comparing maps and tables. Decision Sciences 28 (2), 391–420.

Soman, D., Shi, M., 2003. Virtual progress: the effect of path characteristics on perceptions of progress and choice. Management Science 49 (9), 1229–1250.

Steckel, J.H., Gupta, S., Banerji, A., 2004. Supply chain decision making: will shorter cycle times and shared point-of-sale information necessarily help? Management Science 50 (4), 458–464.

Sterman, L.D., 1989. Modeling of managerial behavior: misperceptions of feedback in a dynamic decision making experiment. Management Science 35 (3), 321–339.

Stading, G., Flores, B., Olson, D., 2001. Understanding managerial preferences in selecting equipment. Journal of Operations Management 19 (1), 23.

Stanton, J.M., Barnes-Farrell, J.L., 1996. Effects of electronic performance monitoring on personal control, task satisfaction, and task performance. Journal of Applied Psychology 81 (6), 738–745.

Steckel, J.H., 1990. Committee decision making in organizations: an experimental test of the core. Decision Sciences 21 (1), 204–215.

Swink, M., 1995. The influences of task and user factors on performance in a logistics DSS application. Decision Sciences 26 (4), 503–529.

Swink, M., Robinson, E.P., 1997. Complexity factors and intuition-based methods for facility network design. Decision Sciences 28 (3), 583–614.

Swink, M., Speier, C., 1999. Presenting geographic information: effects of data aggregation, dispersion and users' spatial orientation. Decision Sciences 30 (1), 169–195.

Taylor, S., 1994. Waiting for service: the relationship between delays and evaluations of service. Journal of Marketing 58 (2), 56–69.

Thieery, M., 1994. Subjective importance of goal and reactions to waiting in line. Journal of Social Psychology 134 (6), 819.

Umanath, N.S., Scamell, R.W., Das, S.R., 1990. An examination of two screen/report design variables in an information recall context. Decision Sciences 21 (1), 216–240.

Vinchur, A.J., Schippmann, J.S., Switzer III, F.S., Roth, P.L., 1998. A meta-analytic review of predictors of job performance for salespeople. Journal of Applied Psychology 83 (4), 586–593.

Wacker, J.G., 1998. A definition of theory: research guidelines for different theory-building research methods in operations management. Journal of Operations Management 16 (3), 361–385.

Whyte, G., 1991. Diffusion of responsibility: effects on the escalation tendency. Journal of Applied Psychology 76, 408–415.

Wong, C.-S., Campion, M.A., 1991. Development and test of a task level model of motivational job design. Journal of Applied Psychology 76 (6), 825–837.

Wu, D., Katok, E. Learning, communication, and the bullwhip effect. Journal of Operations Management, in press.

Zakay, D., Hornik, J., 1996. Psychological time: the case of time and consumer behavior. Time and Society 5 (3), 385–397.

Zavadlav, E., McClain, J.O., Thomas, L.J., 1996. Self-buffering, self-balancing, self-flushing production lines. Management Science 42 (8), 1151–1164.

Zohar, E., Mandelbaum, A., Shimkin, N., 2002. Adaptive behavior of impatient customers in tele-queues: theory and empirical support. Management Science 48 (4), 566–583.