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Success and Failure of Experts and Novices in a Complex and Dynamic Business Simulation

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SUCCESS AND FAILURE OF EXPERTS AND NOVICES IN A COMPLEX AND DYNAMIC BUSINESS SIMLUATION

by

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Abstract

The current study examined the problem solving behaviors of novices and experts in a complex computer simulation. Dynamic decision-making and complex problem solving abilities were analyzed to investigate if experts are the most successful of all participants when simulating the role of CEO of a chocolate factory, CHOCO FINE. Participants included novices, business undergraduate students and psychology undergraduate students, and experts, small business owners. Results revealed that small business owners engaged in the most successful dynamic decision-making strategies. Experts compared to novices had more total monies at the end of the simulation, spent more time in the first two months of twenty-four months, spent less money on information collection overall, made the most changes in representatives and advertising, and less changes in market research. This study addressed the differences between novices and experts not only in performance, but also in behavior in a complex and uncertain situation. The findings from this research enhance the dearth of research in addressing the relationship between behavior strategy and performance specifically in the area of expertise. The research at hand extends the previous literature within the domain of decision-making and provides insight for the differences in behavior strategies between novice and expert subjects.

Keywords: dynamic decision making, complex problem solving, training, expertise, microworlds

Success and Failure of Experts and Novices in a Complex and Dynamic Business Simulation

The research to investigate dynamic decision-making through the use of complex computer simulations was initiated in Europe with the research of Donald Broadbent and Dietrich Dörner (Broadbent, 1977; Dörner, 1980). Together these researchers began to explore what is now deemed Complex Problem Solving (CPS) (Frensch & Funke, 1995). In Complex Problem Solving, the decision-making behaviors of individuals are examined through their interaction with a virtual environment, or a simulated scenario termed a micro-world. The micro-worlds in CPS offer interconnected, uncertain, and dynamic problems, which resemble the problems experienced in real-life (Barth & Funke, 2010).

Dynamic Decision Making (DDM) research also involves the use of dynamic, complex, and opaque variables in a changing environment. Dynamic variables are influenced by the passage of time. A decision at time *t* is dependent on the previous decision made at time *t* - 1 (Gonzalez, Vanyukov, & Martin, 2005). Complex variables have numerous components with several interconnected relationships to each component, which makes it difficult to comprehend the predictably of the microworld. What is difficult for one decision maker may not be difficult for another decision maker as seen in expert verse novice decisions. The decision maker's cognitive capability ultimately influences the complexity of the microworld. Opaque variables are available to the decision maker, but not explicitly. For example, in the microworld of CHOCO FINE the decision maker has a drop-down menu option for market research sales to view competitor profiles. This variable is opaque; if the user is unaware of this option they will not use it. Individuals also experience uncertainty in DDM, as they are subject to engage in ongoing interdependent decisions, some of which are directly controlled by the decision maker themselves and some decisions are affected by the external environment (e.g., a rapid rise in

market prices) (Gonzalez, Lerch, & Lebiere, 2003; Gonzalez et al., 2005). The research on CPS and DDM are closely related, where both posit problem scenarios with several unclear interconnected variables that are dynamic, complex, and obscure (Dörner, 1996; Schmid, Ragni, Gonzalez, & Funke, 2011). An example of CPS and DDM in a microworld includes the WINFIRE simulation, where participants simulate the role of a fire-fighting commander with the task to protect the city from the spread of wild fire. Another example includes the MORO simulation, where participants simulate the role of a developmental aid assistant with the task to improve the living environments of a semi-nomadic tribe over a period of 20 years. CPS research and DDM research overlap immensely with small differences between the two. CPS was traditionally studied in Europe with novice subjects (Schmid et al., 2011) and DDM was more traditionally studied in the United States. To be successful in DDM, one must learn to adapt and remain open to various decisions (Dane, 2010).

The scarcity of literature illuminating the cognitive underpinnings, which occur during dynamic decision making poses a challenge to comprehending real world decision making (Gonzalez et al., 2005). Microworlds offer the best option for experimental control while simulating problems experienced in real life. Ericsson and colleagues' (e.g, Ericsson, Charness, Feltovich, & Hoffman, 2006; Ericsson, Krampe, & Tesch-Römer, 1993; Ericsson & Lehmann, 1996; Ericsson, Prietula, & Cokely, 2007) research on expertise highlights the notion that different individuals (e.g., expert and novices) experience and approach the same problem differently. The goal of the current research is to investigate the strategies of novices and experts in a dynamic decision-making task, and to further extract the most successful strategies, which lead to superior performance.

Research on Expertise

Expert level performance cannot be accounted for by stable heritable characteristics, but instead can be attained through deliberate practice (Ericsson et al., 1993). The state variables of expertise and strategy are ones, which can be influenced. In fact, it has been indicated that the thought processes of experts can be taught directly (Van Gog, Paas, & Van Merriënboer, 2008).

What defines expertise? How do novices and experts differ in their decision-making and cognitive abilities? Hoffman (1996) defines expertise on the cognitive level by three components: development, knowledge structures, and reasoning processes. The development of expertise involves the sequence of the understanding of problems on the surface level, as experienced by novices, to a more thorough conceptual understanding of problems, as experienced by experts; progression from novice to expert is accomplished by deliberate and skill-based practice. Knowledge structures of experts and novices differ in that experts rely on more abstract concepts and rely on schemata, or mental models, to solve problems. Experts are able to make more theoretical distinctions in comparison to novices and possess reasoning flexibility (Hoffman, 1996). Experts also possess the ability to selectively access relevant information also known as selectivity. Experts are able to attune to the important information and discriminate between unnecessary information when presented with a task (Feltovich, Prietula, and Ericsson, 1996).

Throughout the literature experts have displayed more superior pattern recognition skills (Conners, Burns, & Campitelli, 2011; Groot, 1978), engaged in deeper search (Holding, 1992), and displayed better memory in recall tasks (Ericsson, Patel, & Kintsch, 2000). Experts have also been shown to have larger and more complex schemas, or organized knowledge pertaining to a specific concept (Dane, 2010). Experts have resolved problems more effectively than novices in

physics and mathematics (Chi, Feltovich, & Glaser 1981). Experts exhibit schema stability, a component of cognitive entrenchment, where domain schemas are activated by domain related stimuli, and more effective and immediate solutions become readily available (Dane, 2010). Experts have better organization of declarative knowledge, or factual knowledge, and procedural knowledge, or knowledge to perform a task. Experts have better information processing speed and excellent self- monitoring ability (Del Campo, Villora, Lopez, & Mitchell, 2011).

Theory of Deliberate Practice

Expertise consists of a superior performance, the production of concrete results, and can be measured and replicated (Ericsson et al., 2007). The process of attaining expertise involves engaging in what is known as deliberate practice. In deliberate practice an individuals' skills are enhanced and extended as they practice what is unfamiliar to them, a process which can take most individuals a decade to achieve when expertise is the main objective (Ericsson et al., 2007). Deliberate practice has been shown to be helpful for the improvement of expertise across several domains. Deliberate practice has proven to improve the abilities of military academies, as officers are able to provide effective feedback to academies after they engage in a simulated combat scenario. Deliberate practice has proven to be effective in improving charisma of business executives. Charness, TuYash, Krampe, Reingold, and Vasyukova (2005) represented how deliberate practice is effective in improving expertise with their research in the area of chess skill. Expert chess players, or grandmasters, reported more than five times the amount of serious study, an indicator of deliberate practice, in comparison to the other intermediate players in their research.

Fuzzy Trace Theory and SEEK Theory

Expertise research in medicine and criminal justice has shown that experts are able to make more effective decisions than novices, even when relying on less information (Garcia-Retamaro & Dhami, 2009; Reyna & Lloyd, 2006). Expert athletes perform better when a distractor task is presented to them, as thinking less about the task at hand proves to be beneficial; this is not the case for novices (Marewski, Wolfgang Gaissmaier, & Gigerenzer, 2010). Experts tend to engage in less deliberate thinking especially in familiar environments related to their domain (e.g., Ericsson et al. 2007; Marewski, Gaissmaier, Gigerenzer, 2010). Rieskamp and Otto (2006) note that problem solvers initially search all available solutions when presented with an unknown task. After their extensive search, when knowledge has improved considerably, they rely on less information for further solutions. This is consistent with research on what is known as fuzzy trace theory, where individuals rely on gist information processing to reach effective solutions to problems (Reyna & Lloyd, 2006). According to fuzzy trace theory as experts gain more knowledge they are able to rely on less information regarding decision making. Furthermore, as expertise continues to develop through time experts are able to rely on their intuition more to make their decisions (Reyna & Lloyd, 2006). SEEK (Search, Evaluate, and Knowledge) theory (Bilalic, Mcleod, and Gobet, 2009) also supports that successful problem solvers conduct a meticulous search for all solutions to problems. According to SEEK theory, experts search more broadly and are able to evaluate and discriminate between solutions better than novices (Bilalic et al., 2009).

Action-Oriented Problem Solving Theory

According to action-oriented problem solving theory when a problem solver engages in action information pertaining to the solution is revealed more readily for interpretation and

further decision making (Rudolph, Morrison, & Carroll, 2009). The theory was originally developed for expert decisions related to medical diagnoses, but is directly applicable to entrepreneurial environments (Rudolph et al., 2009) such as the environment experienced in CHOCO FINE. Rudolph and colleagues (2009) define the path to a decision as an expansive search to reach the correct answer. In action-oriented problem solving "action based inquiry", or more simply put acting, is the sole way to reveal information that will aid in future action strategies. This point can be further explained by the term "action endogenity" where the act of acting itself directly affects the environment of the problem-solving situation. Action in this sense leads to a more adaptive form of problem solving where action will help avoid failing through vagabonding (e.g., jumping from one area to another without following a detailed plan) and fixation (e.g., fixation on one specific solution, while ignoring any other possibilities). Acting reveals cues and other pertinent information regarding the situation. When the emergence of these cues is slow progressing, fixation is more likely occur. Furthermore, when the emergence of these cues is slow progressing, important information is not revealed and several poor alternative solutions are developed and acted on which are not based on these cues, hence vagabonding is more likely to occur. Furthermore, Rudolf and colleagues (2009) posit that an entrepreneurial business environment, as simulated in CHOCO FINE, is the ideal environment for which action-oriented problem solving is optimal; after a strategy is employed, unexpected information surfaces and market fluctuations arise as a direct result of action on behalf of the individual.

Chunking and Template Theory

According to chunking theory (Chase and Simon, 1973) and template theory (Gobet & Simon, 1996) experts have the ability to rely on previous knowledge from familiar problems to

make decisions. The theory of chunking was originally developed to explain attentiveness and perception in chess, but is directly applicable to other domains of expertise. The concept of chunking relies on the notion that chess players perceive previous positioning of chess pieces as chunks, or semantic units, which are stored in long-term memory. During recall, the information from these chunks is accessed. Expert chess players are exposed to larger chunks due to their extensive practice and study within the domain of chess and have better memorization of these positions in comparison to novices. These chunks serve as precursors to actions that ultimately lead to successful moves within the game of chess (Gobet, 2005). Template theory suggests that knowledge structures become keenly sharpened with extensive experience and repeated to exposure to various stimuli.

The previous theories discussed are relevant to the current study. The theory of deliberate practice states that with extensive thought-based practice expertise is acquired. The experts in this study have engaged in this deliberate practice within their business domain and are expected to perform better than novices. According to fuzzy trace theory and seek theory expert problem solvers will search thoroughly for all solutions and later rely on schemata to reach a conclusion when approaching a problem. For this reason it is expected that the experts in this study will conduct a thorough search for all cues in the beginning of the simulation and then rely on less cues later in the simulation. According to action-oriented problem solving action aids in revealing helpful cues regarding the situation. Combining the theories of SEEK theory and action-oriented problem solving it is expected that experts will search all cues thoroughly before engaging in action. Furthermore, action will help to change the environment of the problem situation revealing more cues for more action strategies. And lastly, chunking and template theory state that chunks, templates, schemata or mental images are sharpened with experience

and exposure to specific stimuli. It is expected that experts will rely on these stimuli when approaching problems experienced within the simulation of CHOCO FINE. Combining fuzzy trace theory, template theory, and chunking theory experts will rely on their own intuition and schemata to resolve problems.

There is a need to study the processes, which lead to the decision making that experts engage in (Van Harreveld, Wagenmakers, & Van Der Maas, 2007). Danner and colleagues (2011) suggest that DDM tasks are helpful for choosing prospective employees and expertise can improve the decision-making abilities utilized in day-to-day job functioning (Ericsson & Lehmann, 1996; Nee & Meenaghan, 2006).

The goal of the current study is to extend previous literature on DDM and CPS with a primary focus on the behavioral strategies, which individuals engage in when presented with an uncertain, dynamic environment. These strategies will then be explored through experts and novices performance, so that the most successful strategies are revealed.

The CHOCO FINE Simulation

Participants who engage in DDM and CPS within a microworld engage in particular strategies to manage the various variables involved in different simulations; these strategies are not always the same from simulation to simulation (e.g., Güss et al., 2010; Osman, 2010; Osman & Speekenbrink, 2011). The current research is concerned with exploring CPS and DDM, which would resemble real world decisions as experienced in the real world. The validity of exploring such a simulation would be only maintained if the simulation at hand reflected the vast complexity of the true business world (Güss et al., 2013). CHOCO FINE is a complex simulation, which accounts for these various interconnected variables, experienced in real life.

CHOCO FINE is a computer simulation developed by Dietrich Dörner, which has undergone three revisions since the original simulation. CHOCO FINE includes more than 1,000 simulated, complex, and interconnected variables across 19 different domains. The overall goal for the simulation is for participants to successfully simulate the role of CEO of a small chocolate factory, CHOCO FINE, located in Vienna. As CEO, participants are responsible for monitoring and managing the production, marketing, advertising and sales of all products; each of the decisions made during the simulation are recorded for later analysis.

The simulation takes place over a 24-month period, two hours real time, where transition and time spent from month to month is left to the discretion of the participant; all decisions for the month are required to be made on the first day of each month. One simplification of CHOCO FINE is that the weeks are only five days, Monday through Friday; months consist of twenty workdays. Participants have access to three main screens in CHOCO FINE: the main screen, the production screen, and the marketing screen.

The main screen portrays the overall balance of total monies projected in a large bar graph, so that participants are always aware of their current progress. The screen also displays production, demand, sales, stock of current inventory, open orders, and deliveries per day. Participants are also able to view data from previous months from this window.

In the production screen participants have access to control the six machines, which are responsible for producing and dispersing the company's eight different chocolates. Participants are able to view the capacity per half day of each of these machines and are able to change the allocation of chocolates for each one.

The marketing screen displays a simulated map of Vienna, in pie charts, where pieces of the pie correspond to the respective market size. Participants are able to view their competitors'

market share holdings relative to the different districts and counties of Vienna. Here participants have the opportunity to engage in detailed information gathering by viewing and purchasing information on the prices of products for further market research. The preferences of their customer base and competitor product profiles (e.g., healthy or young) are accessible for a price. They also have the opportunity to control advertising from this screen, which allows for the participants to change the characteristics of specific products (e.g., bunny chocolate shape at the time of Easter), which will be sold to their selection of specific buyers. Participants have the ability to engage in a proactive strategy, on this screen by manipulating the ten sales representatives responsible for distributing and selling chocolates; participants have the ability to hire, fire, or redistribute these representatives.

Hypotheses

- *Hypothesis 1: Expert-Novice performance*

  Consistent with the previous literature on expert-novice comparisons, it is expected the experts will perform best in the simulation (e.g., Chi et al., 1981; Ericsson et al., 1993; Ericsson et al., 2006; Ericsson et al., 2007; Feltovich et al., 1996; Hoffman, 1996; Van Gog et al., 2008). Experts engage in skill-based deliberate practice throughout their career; this deliberate practice should lead to better success within our simulation. Small business owners (experts) are expected to engage in the most successful strategies followed by business students, and psychology students (novices) respectively.

Information gathering:

- *Hypothesis 2: Depth of initial exploration* can be defined as the amount of time spent working on the first two months of the simulation; those who spend less time, explore in less

depth. Successful problem solvers initially explore every possible cue when presented with an uncertain task (Rieskamp and Otto, 2006). SEEK theory (Bilalic et al., 2009) posits that successful problem solvers search extensively for all solutions to problems. Fuzzy trace theory states that a thorough search of all available solutions to a problem is examined first before making a decision (Reyna & Lloyd, 2006). It is expected that time spent on the first two months will correlate positively with performance.

- *Hypothesis 2a:* It is expected that small business owners (experts) will spend more time in the first two months of the simulation followed by business students, and psychology students (novices) respectively. (Sure, experts could rely on their schemata and templates, yet, the CHOCO FINE situation is new to them and requires checking and updating of their schemata.)

- *Hypothesis 3: Detailed information gathering regarding market.*

To gather detailed information in CHOCO FINE, participants must pay for market research inquiry. We will analyze the cost of market research for the first six months of the simulation and throughout the entire simulation, total/overall. It is hypothesized that the more money spent (for the first six months and total/overall) on detailed information gathering, the better will be the performance.

- *Hypothesis 3a*: It is hypothesized that small business owners (experts) will spend more money on detailed information gathering (for the first six months and total/overall) followed by business students, and psychology students (novices) respectively.

Decision making:

Hypothesis 4: Proactive distribution of representatives

Proactive distribution of representatives, a proactive approach, is defined by the amount of changes, active redistribution and/or hiring, of representatives within the first three months of the simulation, and throughout the entire simulation, total/overall. Across the three months, one can make either make 0, 1, 2 or 3 adjustments. A higher number equates to a more proactive approach, so it is hypothesized that it would correlate positively with performance. According to action-oriented problem-solving theory making a decision relatively early within a problem situation will avoid error and reveal potential solutions (Rudolph et al., 2009).

- *Hypothesis 4a*: It is hypothesized that small business owners (experts) would engage in the most changes in sales representatives in the first three months of the simulation and across the entire simulation followed by business students, and psychology students (novices) respectively.

Breadth of decision making:

- *Hypothesis 5: Market research and advertising changes*

  It is hypothesized that fewer changes, which would serve as an indicator of the existence of a complex schema, in information and market research and advertising in the simulation, correlates with better performance. Consistent with fuzzy trace theory (Reyna & Lloyd, 2006) it is expected that experts will rely on gist-based knowledge to make sound decisions after searching for all possible solutions to a problem. Information is processed in a simple and qualitative fashion. For example, expert physicians base clinical judgment on few key factors when deciding to admit a patient into the hospital (Reyna & Lloyd, 2006). Furthermore chunking theory and template theory state that knowledge structures become more sharpened with exposure to various stimuli (Gobet, 2005).

- *Hypothesis 5a*: It is hypothesized that small business owners (experts) will engage in fewer market research changes and fewer changes in advertising followed by business students and psychology students (novices) respectively.

Method

Participants

Participants were 28 small business owners (experts) from the community where the university is located, 50 business undergraduate students (semi-experts), 72 undergraduate psychology students (novices) from the same university in the Southeastern United States. Participants' ages ranged from 18 to 59 years (M = 28.76, SD = 11.87). The group means were as follows: business students (M = 25.24, SD = 8.10), psychology students (M = 23.98, SD = 7.47), and small business owners (M = 47.43, SD = 8.10). The groups differed significantly in age, F (2, 149) = 99.01, $p < .001$. Participants were 62% female and 37% male. Gender distributions for the respective groups were as follows: business students (30% female and 70% male), psychology students (78% female and 22% male), and small business owners (82% female and 18% male). A chi-square test showed significant gender differences among the three groups, X^2 (2, N = 150) = 34.37, $p < .001$).

CHOCO FINE Instrument

Dynamic decision-making strategies were explored to relate to performance in the CHOCO FINE simulation. Performance was operationalized as total monies at the end of each month. The variables of interest are operationally defined as follows:

(a) Expert-novice performance*:* Performance is operationalized as total monies at the end of each month.

(b) ***Depth of initial exploration***: The amount of time spent working on the first two months of the simulation. Participants are able to control proceeding to the next month of the simulation by clicking the "continue" button after all decisions for the month were made. This is completely discretionary; participants can choose to spend any amount of time they prefer before proceeding on to the next month.

(c) Detailed information gathering regarding market*:* The total cost, represented by the total amount of money expended or spent on purchases for market research inquiry. Participants have access to viewing and purchasing information such as the prices of products.

(d) Proactive distribution of representatives*:* The amount of changes (e.g., hiring, firing, or relocating) of the allocated ten sales representatives in the first three months of the simulation. Across the three months, one can make either make 0, 1, 2 or 3 changes.

(e) Market research changes*:* Participants were able to view and purchase information on the prices of products and purchase consumer information and competitor product profiles. The amount of changes in expenses from month to month were tallied and analyzed. This variable differs from *detailed information gathering regarding market*; *Detailed information gathering regarding market* explores the amount of money expended on information within each month and *market research changes* is defined as the decision changes in this domain from month to month.

(f) Advertising decisions*:* Advertising decisions were defined as those related to money expended for advertising either general overall brand advertising or specific advertising for specific chocolates or specific product profile components.

Procedure

The participants were given thirty minutes to explore the simulation along with an instructional guide before they began simulating the role of CEO. Participants then worked individually for an average of two hours and completed an average of eighteen to twenty-four months of the simulation. Most participants completed an average of nineteen months; for this reason month nineteen was chosen to define overall performance. Every decision that participants' engage in were automatically recorded and exported to a file for later analysis.

Results

Hypothesis 1: Experts versus Novices Performance

A mixed between-within subjects repeated-measures ANOVA was run to investigate differences among the nineteen months and among the three groups in total monies. The interaction between months and groups was significant, Wilks' Lamba =.56, F (38, 214) = 1.93, p = < .001, partial eta squared = .26. The main effects are therefore qualified. The main effect of months was significant, Wilks' Lamba = .188, F (19, 107) = 24.37, p < .001, partial eta squared = .81. The main effect for expertise was marginally significant. The three groups differed marginally in total monies, F (2, 125) = 2.74, p = .07, partial eta squared = .04. The Games-Howell post hoc comparisons of the three groups revealed that small business owners differed significantly from the psychology students in total monies (p = .03). Business students did not differ from the small business owners, however (p = .24). Business students did not differ from psychology students (p = .35). Experts performed best as expected considering performance was operationalized as total monies at the end of each month.

Another mixed between-within subjects repeated-measures ANOVA was run to investigate differences among months seven to twelve and among the three groups in total monies. The interaction between months and groups was significant, Wilks' Lambda = .75, F (10, 260) = 4.13, $p < .001$, partial eta squared = .14. The main effect of month was also significant, Wilks' Lamba = .65, F (5, 130) = 13.73, $p < .001$, partial eta squared = .34. The three groups differed significantly in total monies, F (2, 134) = 3.26, p = .04, partial eta squared = .05. Games-Howell post-hoc comparisons of the three groups revealed that small business owners differed from psychology students significantly (p = .03). Business students did not differ from psychology students (p = .44). Small business owners did not differ from business students (p =. 28).

Another mixed between-within subjects repeated-measures ANOVA was run to investigate differences among months thirteen to nineteen and among the three groups in total monies. We chose to compare months thirteen to nineteen, because most participants did not complete all twenty-four months of the simulation. The interaction between months and groups was significant, Wilks' Lamba = .83, F (12, 240) = 2.02, p = .02, partial eta squared = .09. The main effects are therefore qualified. The main effect of months was significant, Wilks' Lamba = .65, F (6, 120) = 10.82, $p < .001$, partial eta squared =.35. The main effect for expertise was significant. The three groups differed significantly in total monies, F (2, 125) = 3.98, p = .02, partial eta squared = .06. The Games-Howell post-hoc comparisons of the three groups revealed that small business owners differed significantly from the psychology students in total monies (p = .01). Business students did not differ from the small business owners, however (p = .14). Business students did not differ from psychology students (p = .25)

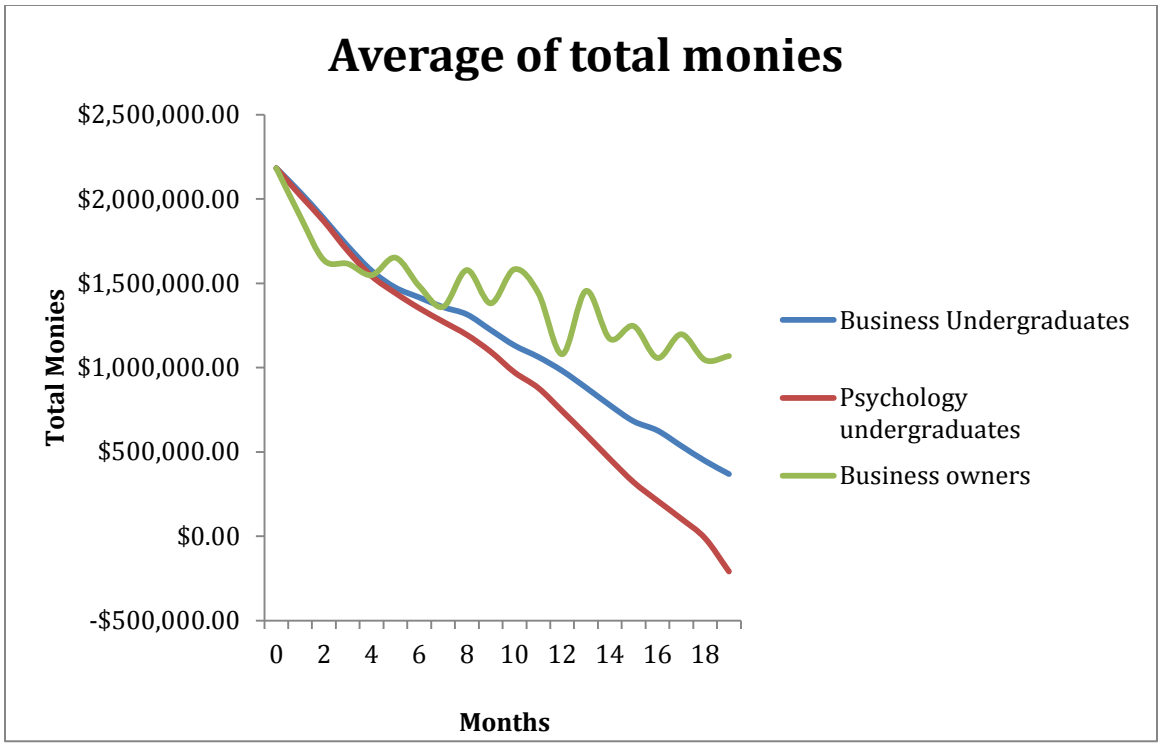

Figure 1: Account balance for the nineteen months of CHOCO FINE for different samples.

Figure 1 reveals the expected results congruent with past research of experts and novices. Small business owners performed the best (total monies), followed by business students and psychology students respectively. The means of the account balance ranged from -5 million to 2.1 million dollars. It is important to note that over 50% of the participants had an account balance over 2.1 million at month nineteen (of twenty-four) of the simulation. These results extend and confirm Ericsson's theory of deliberate practice (Ericsson et al., 2007), which notes that extensive skill-based leads to expert level performance.

Hypothesis 2: Depth of initial exploration

Hypothesis 2 was not confirmed: The amount of time spent in the first two months did not correlate positively with performance (see Table 1). Hypothesis 2a postulated that experts would spend more time in the first two months of the simulation in comparison to novices; this

was confirmed. Table 2 shows that the three groups differed significantly in the amount of time spent in the first two months of the simulation. Tukey-post-hoc test results revealed that small business owners spent significantly more time for the first two months of the simulation compared to psychology undergraduates (p = .03) to gather information and to understand the problem situation. Small business owners did not differ from business students (p = .26). Psychology students did not differ from business students (p = .46). These results are consistent with fuzzy trace theory (Reyna & Lloyd, 2006), which posits that successful problem solvers initially conduct a through search of all cues before reaching a solution.

Experts versus Novices in Decision-Making Strategies

Table 1 shows the correlations between strategies and performance. There was one significant correlation between strategic behavior and performance, defined as total money at month nineteen of the simulation. The amount of advertising changes made was positively correlated with performance. Advertising decisions were defined as money expended on advertising for either branding or specific product profiles; these decisions were tallied and totaled across all months. The more changes participants' engaged in within this domain equated to better performance at the end of the simulation.

There was a significant negative correlation between relative market research changes and depth of initial exploration (time spent in the first two months); this means that participants who spent more time in the beginning of the simulation gathering information, made less changes regarding information later. This was seen in experts; experts spent significantly more time in the beginning of the simulation and made significantly less changes in marketing later in the simulation. It appears that after they gained all relevant information they relied on heuristics and their complex schema to further explore the simulation.

Table 1 also shows a significant correlation between relative market research changes and information expenses across all months (6 and overall); this means that when less money was spent on information, fewer changes in market research were made. There was a significant positive correlation between representative changes and proactive distribution of representative decisions; this means that individuals who made more changes in sales representatives at the beginning of the simulation (proactive distribution of representatives) continued to use that strategy throughout the simulation.

Table 1: *Correlations between total monies and strategies*

	Depth of initial explor-ation	Total inform-ation 6 months	Total inform-ation overall	Proactive distribution of representatives	Represent-ative changes	Advertising changes	Market research changes
Total information 6 months	.13						
Total information overall	-.03	.81***					
Proactive distribution of representatives	.11	.03	-.02				
Representative changes	-.04	-.10	-.07	.50***			
Advertising changes	.02	-.08	-.11	.31***	.28***		
Market research changes	-.20*	.38***	.65***	.03	.03	-.06	
Total money at month 19	.02	-.04	.01	-.02	-.04	.17†	-.14

Note the value of representative, advertising, and market research changes are relative frequencies always divided by the total number of Choco Fine months played. († $p \leq .10$, * $p < .05$, ** $p < .01$, *** $p < .001$).

The strategies among the three groups, small business owners, business undergraduates, and psychology undergraduates were also compared through ANOVA analyses. Table 2 reveals the results from the ANOVA analyses.

Strategies	*df*	MS	F	*p*	ηp2
Depth of initial exploration	2, 137	610.33	4.46	.01	.06
Total money at month 19	2, 126	1.22	4.46	.01	.07
Information expenses 6 months	2, 137	3.53	5.42	.01	.07
Total information expenses	2, 137	5.76	3.47	.03	.05
Proactive distribution of representatives	2, 137	10.94	11.84	<.001	.15
Market research changes relative	2, 137	0.19	4.68	.01	.06
Advertising changes relative	2, 137	1.03	16.52	<.001	.19
Representative changes relative	2, 137	0.28	7.24	.00	.10

Table 2: *ANOVA analyses*

Hypothesis 3: Detailed information gathering regarding market

It was hypothesized that more money spent on information gathering would correlate positively with performance. This was not confirmed (see Table 1). Hypothesis 3a hypothesized that experts would spend more money on detailed information gathering; this was not confirmed.

A mixed between-within subjects repeated-measures ANOVA was run to investigate differences among the nineteen months and among the three groups in total money spent in information gathering regarding market (see Figure 2). The interaction between months and groups was non-significant, Wilks' Lamba = .711, F (38, 224) = 1.10, p = .34, partial eta squared = .16. There was a main effect for month, Wilks' Lamba = .52, F (19, 112) = 5.29, p < .001, partial eta squared = .47. The difference between groups was marginally significant, F (2, 130) = 2.62, p = .08. Games-Howell post hoc tests revealed that small business owners collected significantly less money in information collection in comparison to psychology students (p = .02). Small business owners spent less than business students, but the two groups did not differ

significantly (p = .30). Business students spent less than psychology students, but the two groups were not significantly different (p = .45).

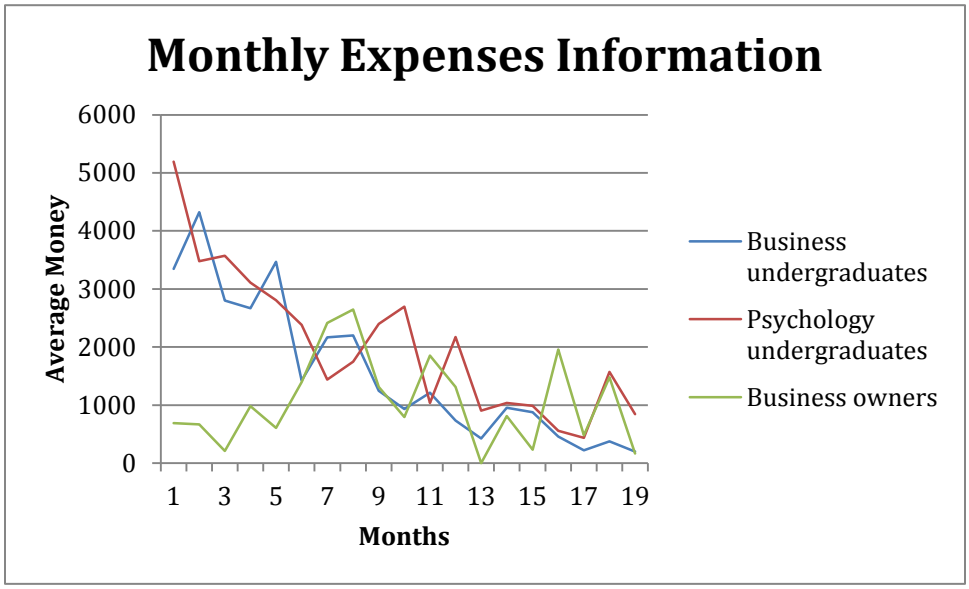

Figure 2: Monthly expenses spent on information in CHOCO FINE for the different samples.

Another mixed between-within subjects repeated-measures ANOVA was run to investigate differences among the month one to month five and among the three groups in total money spent in information collection. The interaction between months and groups was non-significant, Wilks' Lamba =.97, F (8, 260) = .51, p = .85, partial eta squared = .02. There was no main effect for month, Wilks' Lamba = .98, F (4, 130)= .59, p = .67, partial eta squared= .02. The three groups differed in total monies spent on information collection within the first six months of the simulation, F (2, 133) = 68.34, p < .001, partial eta squared = .12. Games-Howell post-hoc test results revealed that in the first six months of simulation, small business owners spent significantly less money on information collection in comparison to psychology students (p < .001) and in comparison to business students (p < .001). Business students spent more money than psychology students, but this difference was not significant (p = .98).

Another mixed between-within repeated measures ANOVA was run on months seven to twelve. The interaction between months and groups was non-significant, Wilks' Lamba = .93, F (10, 264) = .92, p = .04, partial eta squared = .51. The main effect for month was non-significant, Wilks' Lamba = .97, F (5, 132) = .72, p = .61, partial eta squared = .03. The three groups did not differ significantly, F (2, 136) = .41, p = .67, partial eta squared = .01. .

Another mixed between-within repeated measures ANOVA was run on months thirteen to nineteen. The interaction between months and groups was non-significant, Wilks' Lamba = .92, F (12, 258) = .95, p = .50, partial eta squared = .04. The main effect for month was non-significant, Wilks' Lamba = .96, F (6, 129) = 1.02, p = .42, partial eta squared = .05. The three groups did not differ significantly F (2, 134) = 1.14, p = .32, partial eta squared = .02.

Even though it was hypothesized that experts would spend more money on information gathering, it is interesting that the small business owners spent the least amount of money in comparison to the other groups. What is even more interesting is the small business owners spent significantly less in the beginning of the simulation, but did not differ from novices for months seven to twelve or months thirteen to nineteen. This finding, however, is consistent with the research of Reyna and Lloyd (2006) and Rieskamp and Otto (2006) on fuzzy trace theory, as successful problem solvers and experts rely less on information cues, once they have attained familiarity with a situation. Additionally, small business owners may have perceived spending within this domain as a risk.

Decision making

Hypothesis 4: Proactive distribution of representatives

It was hypothesized that small business owners would engage in a proactive approach when presented with a dynamic task. Table 2 shows that there were significant differences

among the three groups regarding a proactive distribution of representatives within the first three months of the simulation. Tukey's post-hoc results revealed that small business owners made the most changes amongst their representatives in comparison to business students ($p < .001$). Small business owners also made more changes in representatives in comparison to psychology students ($p < .001$). Business students made more changes than psychology students, but did not differ significantly ($p = .86$).

It was also hypothesized that small business owners would make the most changes in sales representatives throughout the simulation. Comparing the total number of changes in representatives relative to months played throughout the entire simulation, Games-Howell post-hoc results revealed that small business owners made significant more changes in comparison to business students ($p = .05$). Small business owners differed marginally from psychology students ($p = .06$). Business students did not differ from psychology students ($p = .94$). These results are consistent with action-oriented problem solving theory (Rudolph et al., 2009).

Hypothesis 5: Market research and advertising changes

It was hypothesized that the less changes in market research would correlate with performance and this was not confirmed (see Table 1). However, it was also hypothesized that small business owners would engage in the least amount of market research changes in comparison to novices; this was confirmed. Business students, small business owners, and psychology students significantly differed in the amount of market research changes made ($p = .01$) (see Table 2). Comparing the total number of market research changes relative to months played, Tukey's post-hoc results revealed that small business owners made significantly fewer changes in comparison to psychology students ($p = .01$). Business students did not differ

significantly from small business owners (p = .44). Business students did not differ from psychology students (p = .12) (see Figure 3).

Comparing the total number of changes in advertising relative to months played, Games-Howell post-hoc results revealed that small business owners made significantly more changes in advertising in comparison to business students (p < .001) and also made significantly more changes in comparison to psychology students (p < .001). Business students and psychology students did not differ (p = .15).

Figure 3 displays the breadth of decision-making strategies for hypothesis 4a and 5. As depicted, small business owners made the least amount of changes in market research and the most changes in both advertising and representatives.

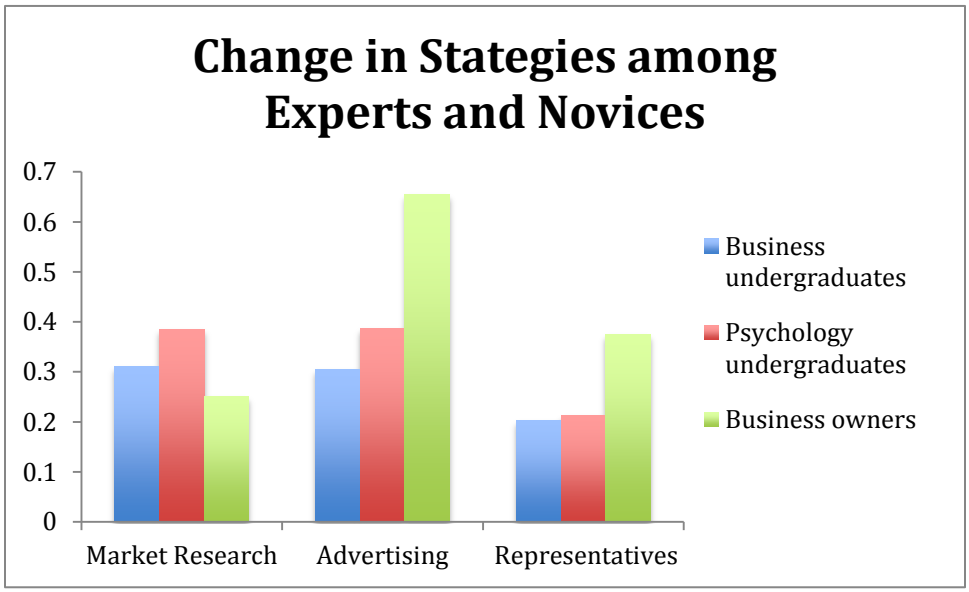

Figure 3: Number of changes relative to number of Choco Fine months played in market research, advertising decisions, and sales representatives decision

A mixed between-within subjects repeated-measures ANOVA was run to investigate differences in money spent among the nineteen months and among the three groups in advertising (see Figure 4). The interaction between months and groups was significant, Wilks'

Lamba =.61, *F* (38, 223) = 1.62, *p* = .02, partial eta squared = .22 The main effects are therefore qualified. The main effect of month was significant, Wilks' Lamba = .66, *F* (19, 111) = 3.01, *p* < .001, partial eta squared = .34. The three groups did not differ in total monies spent on advertising, *F* (2, 129) = .59, *p* = .58, partial eta squared = .01.

Another mixed between-within subjects repeated-measures ANOVA was conducted to compare the differences between groups in month one to five in expenses on advertising. The interaction between months and groups was significant, Wilks' Lambda = .84, *F* (10, 264) = 2.37, *p* = .01, partial eta squared = .08. The main effect for month was significant, Wilks' Lamba = .86, F (5, 132) = 4.00, p < .001, partial eta squared = .02. The groups did not differ significantly, *F* (2, 136) = .99, *p* = .38, partial eta squared = .01.

When comparing month seven to month twelve in expenses on advertising, the groups did not differ significantly, *F* (2, 132) = .36, *p* = .70, partial eta squared = .00. The interaction between months and groups was significant, Wilks' Lambda = .87, *F* (10, 256) = 1.91, *p* = .04, partial eta squared = .07. The main effect for month was not significant, Wilks' Lamba = .92, *F* (5, 128) = 2.14, *p* = 07, partial eta squared = .08.

When comparing only months thirteen to nineteen, the three groups did not differ significantly from each other. The interaction between months and groups was significant, Wilks' Lamba =.91, *F* (12, 248) = 1.00 (*p* = .45), partial eta squared = .05. The main effect of months was non-significant, Wilks' Lamba = .96, *F* (6, 124) = .91, *p* = .50, partial eta squared = .04. The three groups did not differ in total monies spent on advertising for months thirteen to nineteen, *F* (2, 129) = .95, *p* = .39, partial eta squared = .02.

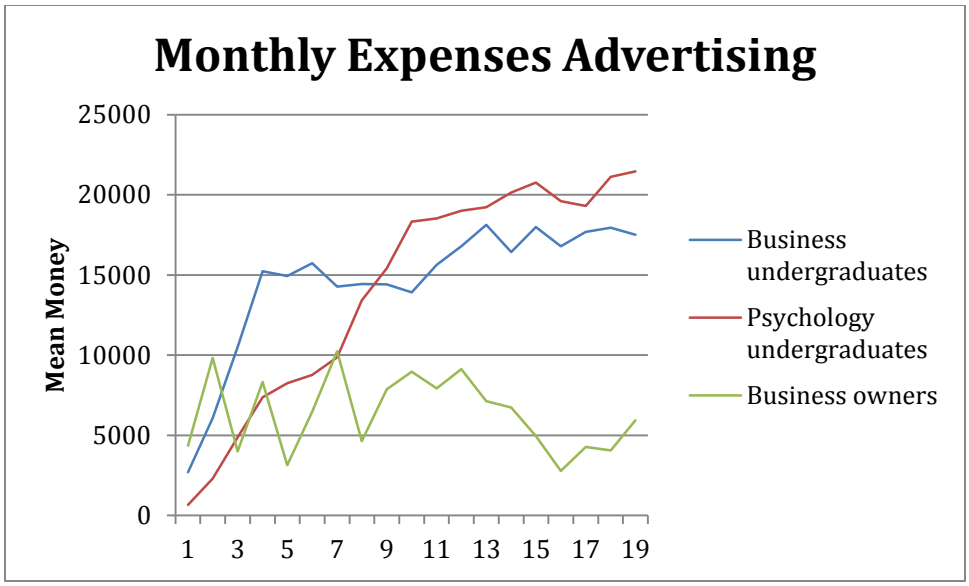

Figure 4: Average amount of expenses spent on advertising for different samples.

Discussion

The purpose of this research was to explore the behavior strategies which experts and novices use when engaging in a dynamic decision-making task. The research at hand extends previous literature of deliberate practice (Ericsson et al., 2007), fuzzy-trace theory (Reyna & Lloyd, 2006), chunking theory (Gobet, 2005), template theory (Gobet, 2005), action-oriented problem solving theory (Rudolph et al., 2009), and SEEK theory (Bilalic et al., 2009). The theory of deliberate practice states that with skill-based practice knowledge structures are sharpened and expertise is attained. The experts in our study outperform novices because they have acquired several years of deliberate practice. The literature on fuzzy-trace theory and SEEK theory is extended because the experts in our study spend more time in the beginning of the simulation searching for cues and less money on information gathering later in the simulation, essentially relying on their intuition to guide their decisions. Furthermore, experts in our study relied on their schemata, chunking, and templates to guide their decisions regarding information

collection as well. This research contributes to the ambiguous and inconsistent literature on expert problem solving. Previous expert literature on problem solving has proven to be inconsistent (Bilalic et al., 2009). For example, it is unclear if experts and novices use different employ different strategies when solving a problem. The current study indicates that novices and experts differ in their behavior strategies. It is unclear if experts use the same strategies to solve all problems or if they employ different strategies. The current research suggests that experts employ different strategies based on the problem itself.

Ericsson and colleagues (2007) note that deliberate practice involves methodical thought and reflection. Deliberate practice also involves two opportunities to acquire knowledge by improving and extending the skills one already possesses. Ericsson and colleagues (2007) further posit that with the right guidance from well-trained mentors and with appropriate constructive feedback that focuses on weakness that should be improved within the individual, expertise can be attained. The microworld of CHOCO FINE is unique because it provides business apprentices the opportunity to engage in deliberate practice with immediate feedback.

Several hypotheses were confirmed. The expert-novice hypothesis was confirmed. Small business owners performed better with more total monies remaining at the end of the simulation in comparison to novices. Congruent with research on expert-novice differences (Ericsson et al., 1993; Ericsson et al. 2006) experts performed better because they have experience in engaging in what is known as skill-based deliberate practice, where an individual consistently engages in an unfamiliar skill, essentially strengthening it, a process which takes years to accomplish. The experts in our simulation have attained experience through deliberate practice within their individual expert domains; this is why they were able to perform so well. The experts in our study lead their own small businesses; the skills obtained from heading a company are closely

related to the skills required to perform well within CHOCO FINE. For example, a small business owner has experience with advertising decisions, which are essential for persuading and encouraging customers to purchase one's products. Small business owners have experience with proactive distribution of employees; they are responsible for hiring new employees, if there is a demand for it or for firing employees if the cost is too high to reimburse them for their services. Small business owners also have the opportunity to strengthen their skill set regarding the reaction to sudden unexpected changes due to a rising or falling market.

Expert-novice comparisons revealed that small business owners spent more time in the first two months of the simulation in depth of initial exploration than novices. Why did experts spend more time exploring the simulation? This can be explained by Holding's SEEK theory, where experts rely on analytical reasoning skill and search more extensively for solutions to problems. Experts have the ability to make better judgments because they are able to search for solutions more effectively relying on their own knowledge for guidance (Bilalic et al., 2009). These results are also consistent with fuzzy-trace theory (Reyna & Lloyd, 2006), where problem solvers search for many available solutions when presented with a problem.

Results revealed that experts spent more time, specifically in the first two months of the simulation, but less money on detailed information gathering in comparison to novices. Two months was an adequate amount of time for experts to plan accordingly for future decisions. During this time experts were able to decide which variables were most important for manipulating. This may be why they spent less on detailed information gathering later in the simulation. Detailed information gathering is calculated by the cost spent on market research, where participants pay for each inquiry. Consistent with chunking theory and template theory (Gobet, 2005) experts may have relied on their previous knowledge from familiar problems to

make their decisions. This previous knowledge served as a precursor to actions that ultimately led to successful moves within the CHOCO FINE simulation. Also, consistent with template theory, which suggests that knowledge structures are enhanced with experience and exposure to various stimuli, small business owners relied on these sharpened knowledge structures when deciding to spend less on detailed information gathering. According to fuzzy-trace theory (Reyan & Lloyd, 2006), experts initially engage in a thorough search of knowledge when presented with an unknown task and later rely on less information to make more effective decisions. Experts spent a sufficient amount of time in the beginning of the simulation (more than novices) and did not need to spend the additional funds for further information gathering. Medical professionals and criminal experts have display this same pattern (Garcia-Retamaro & Dhami, 2009). Furthermore small business owners may have spent less on market research expenses because they wanted to minimize costs and minimize the risk associated with spending in this domain in comparison to psychology and business students. Wagenera and colleagues (2010) suggest that small business owners may be less inclined to engage in high-risk behaviors. They further note that there is research to indicate a negative correlation between high risk and business success (Wagenera et al., 2010).

The experts' who participated in this study were small business owners. It is important to differentiate between entrepreneurs and small business owners (Wagenera, Gorgievski, & Rijsdijkb, 2010). Business owners may place certain values on specific variables, which will influence the decisions to run their business. For example, business owners with the attributes of power and achievement value business growth and place importance on growing a larger business in comparison to those who do not value power. Business owners who possess the attribute of benevolence value the needs of their customer satisfaction (Wagenera et al., 2010).

Wagenera and colleagues (2010) further suggest that entrepreneurs have a tendency to engage in higher risk in comparison to small business owners. Also, entrepreneurs place high importance on market orientation, or understanding customer needs and competitor threat. Mazzarol and Reboud (2006) further advocate that attuning to buyers' needs is an important quality for successful entrepreneurs.

Experts made fewer changes in information gathering. Experts also spent less money on advertising and information throughout the simulation. Expertise when it is related to spending money on these three domains was related to a more stable decision-making approach. This finding is consistent with other research showing that when participants are overwhelmed by a complex and uncertain problem they often engage in "thematic vagabonding" (Dörner, 1996). Thus, novices showed more of this thematic vagabonding behavior compared to the experts. For example, they did not follow a detailed plan, but instead jumped from variable to variable within the simulation.

It is interesting that experts engaged in less market research changes and more advertising changes throughout the simulation. These two domains are closely related. It appears that experts attributed risk with one variable and not with the other. A follow up study could explore the risk value that experts place on both advertising and market research and the differences, if any, between them.

Expert-novice comparisons regarding proactive distribution of representatives (e.g., hiring, firing, and redistributing sales representatives) divulged that experts made the most changes for representatives in the first three months of the simulation in comparison to novices. Further analysis revealed that experts also made more changes for representatives across all of the months of the simulation as well as more advertising changes throughout the simulation in

comparison to novices. Why did experts make more changes in proactive distribution of representatives, representatives and advertising? Consistent with experts ability to selectively attune to the important and relevant information when presented with a specific task (Feltovich et al., 1996), it appears that experts are able to choose which variables need to be attended to- in this case changing representatives and advertising changes was the optimal choice. According to the action-oriented problem solving theory (e.g., Rudolph et al., 2009) a quick pace of action will avoid failing and other errors (e.g., vagabonding and fixation). Action itself reveals helpful information pertaining to the current problem situation. If this information is revealed too slowly by not acting, then the problem solver may become stuck on one solution or may begin to jump from poor solution to poor solution instead. The entrepreneurial business environment, as simulated in CHOCO FINE, is ideal for action-oriented problem solving, but only within the domain of advertising and sales representatives. The dynamic interaction between decisions made by the decision maker and the response from the environment are closely tied to one another in CHOCO FINE; acting in a quick fashion for these two domains ultimately reveals helpful information more quickly, which leads to the better performance. Regarding the other domains in CHOCO FINE, actions that are based on feedback from the previous month lead to the best performance.

Only one of the nine strategies correlated with performance. Why did the other hypothesized strategies on information collection, depth of exploration, feed forwarding, and breadth of decision-making strategies not correlate with performance? This may be because there are seven steps to problem solving and our current study only addressed two of them. The seven steps of problem solving are: problem identification, goal definition, information gathering, elaboration and prediction, planning, decision making and action, and evaluation (see e.g.

Dörner, 1996; Güss et al., 2010). Furthermore, because CHOCO FINE is a complex and dynamic microworld, with over 1,000 interconnected variables it is difficult to correlate performance with a few specific variables. (Schmid, Ragni, Gonzalez, & Funcke, 2011). In CHOCO FINE, there is not one specific solution to obtain the optimal success, there are many courses consisting of various decisions, which can lead to a positive performance. Although, this poses a challenge for correlating each individual variable with performance, it is a facet of the ecological validity of CHOCO FINE; in the real business world there are many routes that may lead to success. Future research could assess behavior patterns which experts engage in to ultimately lead to success in the business world. Future research could also focus on the planning process (one of the steps of problem solving) which experts engage in before they engage in decision-making, so that their cognitive processes are better understood. The cognitive processes, which experts engage in is greatly understudied. Future research on the subject would greatly benefit the field of psychology. These processes and behavior patterns could then be taught, so that deliberate practice would strengthen the skill set of novices, as well as those who endeavor to become an expert in a specific domain.

Another interesting finding that this research divulges is the effect of time on decision-making behavior. We analyzed the behavior strategies of the participants in four different time segments: months one to six, seven to twelve, thirteen to nineteen, and overall. Experts employed different strategies in the beginning of the simulation; three of our hypotheses (specifically hypotheses 2, 3, and 4) revealed significant differences in strategies employed by experts within the first six months of the simulation. Experts spent more time in depth of initial exploration in the first two months of the simulation, less money in detailed information gathering in the first six months of the simulation, and made the most changes in sales representatives in the first three

months of the simulation. These results are most interesting because the gap between novices, psychology students and business students, and experts in these three strategies appears to be bridged at month six of our simulation; these differences do not exist in later months. However, it is important to note that at the end of the simulation the gap between novices and experts is explicit with novices having significantly less money than experts. Referring to the strategies of depth of initial exploration, detailed information gathering regarding market and proactive distribution of representatives it may be that novice participants are learning during this dynamic decision-making task. Ericsson and colleagues (2007) note that although the development of expertise takes an extensive period of time, deliberate practice can be applied to the development of business expertise. They note that business schools typically have their students simulate real life scenarios, similar to those experienced within in CHOCO FINE, and the students are able to review their failure and success of the simulation afterwards. The students essentially engage in a form deliberate practice and have the opportunity to fix the mistakes they make by repeating the simulation several times. In deliberate practice an individual has the opportunity to strengthen their current skill set and further expend that skill set (Ericsson et al, 2007). CHOCO FINE is unique in that each participant has the opportunity to view his or her progress from the main screen in real time. The main screen portrays the overall balance of total monies projected in a large bar graph. The bar graph is updated from month to month within the simulation. In this regard, participants are able to see if the decisions they made in the previous month lead to success (depicted by an increase in total monies) or failure (depicted as a decrease in total monies). This type of informative feedback may serve as a form of deliberative practice and may be what bridges the gap between experts and novices in depth of initial exploration, detailed information gathering, and proactive distribution of sales representatives within our simulation.

Although Ericsson's theory of deliberate practice poses that expertise development takes several years to acquire the tool of CHOCO FINE may be used over time to help accomplish this. Van Gog, Ericsson, Rikers, and Paas (2005) indicate a need to study the informative feedback experienced in deliberate practice in a longitudinal design. Our research may provide insight to the learning that problem solvers experience during a deliberate practice task. Future research could explore if learning does occur during the simulation. Participants could take the simulation more than one time. If the performance increases, than this assumption would be validated.

Limitations

One limitation of our research is the gender distribution: participants in our study were 62% female and 37% male. A chi-square test showed significant gender differences among the three groups. Future research could further explore the type of learning that occurs, if any, during the dynamic decision making task. This could be accomplished by the use of a think-aloud loud task or by conducting a longer experiment by having participants retake the simulation after critical effective feedback is provided from experts.

Conclusion

This study extends the current literature and contributes to the lack of empirical research on successful and failing dynamic decision-making strategies. These strategies have yet to be associated with performance in DDM (Güss et al., 2013). The literature on expert problem solving has been ambiguous and inconsistent (Bilalic et al., 2009). There is a need to study the decision-making which experts engage in and the processes which underlie them (e.g., Qudrat-Ullah, 2008; Spector, 2008; Van Gog et al., 2007).

Previous research on problem solving has indicated that the strategies, which experts engage in, will be useful for programs which will train future experts (Williams, Papierno, & Makel, 2004). Exploring the behaviors of potential employees in DDM simulations would be advantageous for the business field (see Danner et al., 2011; Ericsson & Lehmann, 1996; Nee & Meenaghan 2006).

Because expert level performance can be attained and influenced (Ericsson et al., 1993; Van Gog et al., 2008), it would be advantageous for novices to engage in unfamiliar skill-based practice and concentrate on the strategies that lead to success after engaging in this task. Novices have the opportunity to engage in this deliberate practice with the CHOCO FINE simulation. This research has several implications for the strategies, which lead to success in a problem situation. For example, novices could directly learn from the successful strategies experts display in similar situations. Novices could benefit from gathering more detailed information when initially presented with a problem. Novices could also benefit from engaging in action relatively early, after the appropriate information is assessed, to reveal pertinent information for future decisions. And finally novices will benefit from employing a stable decision-making strategy associated with low risk that is consistently employed when presented with a problem.

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PRESENTATIONS

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