# Evidence of Swarm Intelligence in Collective Cultures: Identifying the Use of the Swarm Goal Directive of Productivity in Pacific Organisation Systems as well as Between Genders

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***Editors note:*** *The author presented this poster at the symposium as a 'work in progress'. The paper explores the literature and concludes with a methodology and procedure for her future exploration of swarm intelligence in collective cultures. To find out the results of the study, please contact the author directly at: Maneka@byuh.edu*

Intrigued by the existence of societies outside that of the human population, scientists have ventured to study social aggregations within insects to seek insights on effective colonizing. The most popular of these social aggregations are colonies of ants and bees. In studying these groups of social insects researchers have developed algorithms loosely termed swarm intelligence that increase work efficiency within businesses and other social organizations (Bonabeau & Meyer, 2001). A subsequent proliferation of research in surrounding fields has allowed for investigation of key variables that improve work on a global scale (Bonabeau & Meyer, 2001). James Kennedy (1999), an initiator of swarm research, has suggested that there is a high correlation between systems that rely on each other for information and greater task accomplishment.

The results of the Kennedy (1999) study indicates that intelligence is not an effect of individual genius but rather a global accomplishment produced by individuals operating on basic rules. A further study of ants exploited the idea that choices of nesting and food sources depend on both factors based on individual and collective levels (Dussutour, Deneubourg, & Forcassie, 2005). Audrey Dussutour along with Stamtios, Deneubourg, and Forcassie (2006) established this concept by studying collective decision-making in ant colonies that forage under crowded conditions. Results implicate that in addition to choosing shorter paths to food sources, ants also choose wider paths, a decision based on space for the entire colony rather than particular individuals (Dussutour et al. 2006).

Thomas Schmickyl and Karl Crailsheim (2004) researched foraging decisions in bees based on costs and benefits. Results concurred the colony of bees were able to avoid large fractions of possible costs while operating under the colonial paradigm to maximize net gain (Schmickyl & Crailsheim, 2004).

So great is the success of collective operating systems that applications derived from ant and bee optimization algorithms have been incorporated in a variety of technical applications (Dorigo, DiCaro, & Gambardella, 1999) These colony optimization algorithms are based on a list of key elements. The list includes the assignment of basic rules of operation at the individual level, decentralized task division and pheromone communication (Bonabeau & Meyer, 2001). Since its first origination the list of independent variables affecting work quality has grown.

James Kennedy (1999) further studied collective behavior in terms of behavior of the individuals within the system. Behavior on and the individual level is termed particle swarm. James Kennedy (1999) suggests that particle swarm implications exist for beings within a given sociocognitive space. Kennedy used eleMental's (a name used to identify the artificially intelligent robots) to asses the power of collective decisions between cooperating and non cooperating particles (Kennedy, 1999). When assigned simple tasks eleMentals that generated higher amounts of swarming were significantly better at accomplishing tasks (Kennedy, 1999). The results of this study were attributed to a form of distributed cognition.

Pierre Poirier and Guillaume Chicoisne (2006) argue that in a sense swarming is a form of distributed cognition evident in human populations. Distributed cognition provides for the accomplishment of global tasks independent of intelligence levels of individuals within any swarm system. Rather than boost

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intelligence in one particle, the swarm system arrives at accomplishment of complicated tasks as a result of systemic cognition of relatively unintelligent individuals (Poirier & Chicoisne, 2006).

Given that swarming is evident in humans and that swarming is a feature of a collective effort, is swarming greater in collective versus individualistic human cultures?

Consider James Kennedy's (2006) implications that swarm efficiency is greater between swarm societies- collective groups rather than individual agents acting at random. Granted the study revolved around less sophisticated models than the human brain but there is evidence to suggest that collective societies thrive in decentralized systems. Jannette Mageo (2002) infers that specifically members of Tongan and Samoan societies conduct their activities after a manner of embedded psychosocial rules just as swarm colonies do. These psychosocial rules have contributed to the advancement of such societies despite the lack of success in other areas of development. Consider the Tongan economy for example; Odden Harold (2006) reports that economic stability in the Tongan government system is due to contributions from family living abroad not economic progress in terms of export revenue. Examples such as these suggest a form of colonization or swarm intelligence that allows societies such as these to accomplish global tasks through distributed intelligence. Individuals in such systems are not required to be experts at accomplishing tasks on a global scale; rather they are required to be experts at accomplishing relatively basic directives.

Hence logic suggests that societies in which psychosocial rules have been effective in perpetuating culture and work ethics would show a greater tendency to swarm. Due to the existence of multiple aspects of swarm intelligence this literature base will focus on only one aspect of swarming that is productivity in task accomplishment. The first hypothesis is that collective cultures will have a higher productivity rate than individualistic cultures. Under this hypothesis the independent variables will be race, categorized by two representative cultural groups.

The first independent variable will consist of two factors, Caucasian Americans, representative of individualistic societies and Pacific Islanders- collectivist society. These social representations are modeled after Kennedy's (2006) study of collective versus individualistic cognitive systems.

The dependant variable will be a measure of productivity in terms of output per given time (Schmickyl & Crailsheim, 2004; Gray, 2005). Schmickyl and Crailsheim found that when foraging, bees were able to manage cost and benefit fluctuations to provide for better production. Hence, this suggests that inherent swarming tendencies would be evident in the ability to stimulate higher productivity output.

A further independent variable of interest is that of gender, male versus female. The differences between genders have not been studied previously with regard to ants and bees (Bonabeau & Meyer, 2001; Schmickyl & Crailsheim, 2004; Dussutour et al., 2006). However gender differences are significant in human populations. The second hypothesis emerges from studies of hunter gatherer societies that illustrate that because males are often hunters or foragers and women gatherers there are obvious differences in gender roles (Hawkes, 1993). This study base approximates that there will be a significant difference between productivity rates between males and females. This hypothesis is also a further extension of James Kennedy's (1999) conclusions that social cognition is inherent in social beings and as such productivity is higher among collective cognitive efforts. Hence this study will compare gender with the same dependant variable productivity.

The above variables are but a fraction of swarming factors however with further study remaining variables could be analyzed within the human population. The results will aid in arriving at an answer that identifies the power of collective cultures in terms of inherent swarming. If collective cultures exhibit a higher tendency to swarm then more effective approaches to organizational processes may be derived to allow organizations within these cultures to thrive.

## Method

### *Participants*

The study required two sample sets. The first sample comprised of two different racial groups, Polynesians and Caucasian- American as a representation of collective and individualistic cultures. Race was determined as a factor of both birth and country of origin. The second sample set required two gender groups, male and female. Participants' ages fell between the ranges of 18- 35. The samples were selected at random from the Brigham Young University- Hawaii campus specifically students of psychology courses and student members of cultural clubs who were invited to participate. The invitations were extended via announcements in various classrooms and electronic mail. To allow for a normal distributive curve as ascribed by the central limit theorem the minimum of 32 participants were assigned to each group (Annis, 2007). Each sample group contained 64 participants. The number of participants totaled 128. Participants of the second gender based sample group were not selected for race and were only randomly selected for gender.

*Apparatus*

Swarm intelligence when applied to business foraging allows for greater work efficiency (Bonabeau, 2001; Pierre & Chicoisne, 2006). Efficiency as ascribed in business is measured in terms of output per given time (Gray, 2005). Hence, the experiment required the use of a standard timer to mark the five-minute limit per trial. Plastic balls, also named morsels, represented productivity output and a yard stick to measure out standard distances to food sources.

Teamwork within swarm intelligent systems is also largely self organized and decentralized where groups aggregate to accomplish a task (Bonabeau, 2001). Therefore two video cameras were used to record the system to record evidence of aggregation. In addition to this a tally sheet accounted for each individual contribution, source selection and demographic information. A general demographic sheet was used containing name, age, gender, ethnicity, country of birth, a list of countries lived in and time spent in each country in years.

*Procedure*

The following experiment was modeled after patterns previously used to measure swarm (Schmickyl & Crailsheim, 2004; Dussutour et al. 2006). A typical front yard was used as the stage for the experiment. There were four representative food sources (basket of plastic balls) strategically hidden along the field. The first two were placed at opposite directions ten feet away from the starting point; in this case the entrance. The second pair was placed at twenty feet from the entrance also in opposite directions. The food sources were color coded. The color blue corresponded to food source one (fs1) placed on the right at ten feet. The color red corresponded to (fs2) on the left at ten feet. At twenty feet (fs3)/yellow/right and (fs4)/green/left were ascribed accordingly. Each food source contained a hundred morsels. Cameramen were directed to stand encompassing the stage and were instructed to record the experiment.

The experiment was conducted on four separate days. Day one was assigned to Caucasian- Americans and day two was assigned to the Polynesian group. Subsequent days three and four were assigned to males and females respectively. Participants were not informed of other participating groups to avoid competition. Upon entering the stage, participants were required to register their names on the tally sheet and fill out the demographic survey. Individuals were provided with private notes containing three specific instructions representative of basic simple rules used by ants in foraging.

The rules were (1) Forage for or find morsels, (2) Carry morsels one at a time to base point, (3) Within five minutes obtain as many morsels as possible. All trials allowed a time limit of five minutes measured by a timer. Every time a participant returned to the base with a morsel a check mark was granted by the experimenter on the tally list under the choice of food source that the morsel was retrieved from. After each day in the experiment a group total was derived for number of morsels collected in each trail and tally sheets were gathered. Upon conclusion of each trial participants were asked to sign out, thanked and allowed to leave.

**Results**

The results comprised of a 2x2 (race x gender) ANOVA for productivity. The productivity model in this literature base is patterned after the Thomas Schmickyl et al (2004) study of cost and benefit of swarming in bees. The independent variable race had two levels, Polynesian and Caucasian-American. Likewise the second independent variable, gender, had two categories, male and female. These two variables were evaluated as predictors of productivity. Standard economic measures were used to calculate productivity (Schmickyl & Crailsheim, 2004). Therefore, productivity was first analyzed using a standard productivity equation provided below (Gray, 2005).

*Productivity = Value (morsel count)/Time*

Morsel count was a measure of the number of morsels collected by each group. Number of morsels collected per trail was added and divided by a standard time of five minutes. The productivity totals provided the dependent variable for the data set to compare to the independent variables of race and gender. The partial eta squared coefficient was used to appropriate effect size of the data set. The partial eta squared coefficient helped determine the magnitude and strength of the relationship between two variables (Becker, 1999). To identify significantly different means within the data set, a Post HOC test - the Tukey HSD Test - was used. Previous studies effectuated the Boneferroni test; however, for this literature base, the Tukey HSD Test (a less severe measure) was sufficient. Previous studies used the Boneferroni to account for the mathematical assumptions used on the various mathematical models used in the experiment. This experiment has but one mathematical model therefore there isn't a need to place additional restrictions than the ones provided by the standard Tukey test.

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