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# An Agent-Based Approach to Study the Producer-Scrounger Game in Humans

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In social foraging situations, group members choose between two strategies: (a) actively engage in searching for resource sources (Producing); or (b) join a resource source previously discovered by another group member (Scrounging). Two predictions of the Rate-Maximization Model are: (a) the proportion of producers will be lower in conditions where the group size is larger; and (b) the proportion of producers will be lower in conditions where the number of resources is higher. While these predictions have been tested across various species, the number of studies involving human participants remains relatively low. Using an agent-based model approach, we propose a Direct Interaction Task to study the producer-scrounger game in human participants. In this online behavioral task, a single participant moves freely within the habitat and competes for resources against agents. The study involved 80 university students assigned to one of four conditions that varied by group size (G4, G8) and the number of prey (F5, F15). The results show a decrease in the producer index when the group size was larger; however, no effect was observed for the number of prey. This study highlights the potential for investigating social foraging in controlled environments without extensive physical space.

*Keywords*: agent based model, food units, group size, human, producer scrounger game

# ヒトにおける生産者-漁り屋ゲームを研究するためのエージェントベースアプローチ

社会性採食の状況では、グループのメンバーは以下の 2 つの戦略のどちらかを選択する。 (a) 積極的に資源 源を探す(生産者); もしくは(b) 他のグループメンバーが以前見つけた資源源に合流する(漁り屋)。率最大化モデルは、以下の 2 点を予測する。(a) グループの規模が大きい状況ほど、自ら資源を探す生産者の割合は小さくなる。(b) 利用可能な資源の数が多い状況ほど、生産者の割合は小さくなる。こうした予測はさまざまな生物種で検証されているが、ヒトを対象とした研究は依然として比較的少ない。我々はエージェントベースモデルの手法を用いて、ヒトの参加者における生産者-漁り屋ゲームを研究するための直接的相互作用タスクを提案する。このオンライン行動課題では、単独の参加者が仮想生息地内を自由に移動し、エージェントと資源獲得を競う。この研究では、80 人の大学生が、グループのサイズ (G4、G8) と獲物の数 (F5、F15) によって異なる 4 つの条件のいずれかに割り当てられた。実験結果は、グループサイズが大きくなるにつれて生産者指数が低下することを示したが、獲物の数に関しては影響が見られなかった。この研究は、広大な物理的空間がない管理された環境で社会性採餌を調査できる可能性を強調している。

キーワード：エージェントベースモデル、食物単位、グループサイズ、ヒト、生産者ー漁り屋ゲーム

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# Un Enfoque Basado en Agentes para Estudiar el Juego Productor-Aprovechador en Humanos

En situaciones de búsqueda social de alimento, los miembros del grupo eligen entre dos estrategias: (a) participar activamente en la búsqueda de fuentes de recursos (Producir); o (b) unirse a una fuente de recursos previamente descubierta por otro miembro del grupo (Aprovechar). Dos predicciones del modelo de maximización de tasas son: (a) la proporción de productores será menor en condiciones donde el tamaño del grupo sea mayor; y (b) la proporción de productores será menor en condiciones donde el número de recursos sea mayor. Si bien estas predicciones se han probado en varias especies, el número de estudios con participantes humanos sigue siendo relativamente bajo. Utilizando un enfoque de modelo basado en agentes, proponemos una tarea de interacción directa para estudiar el juego productor-aprovechador en participantes humanos. En esta tarea de comportamiento online, un solo participante se mueve libremente dentro del hábitat y compite por recursos contra los agentes. El estudio involucró a 80 estudiantes universitarios asignados a una de cuatro condiciones que variaban según el tamaño del grupo (G4, G8) y el número de presas (F5, F15). Los resultados muestran una disminución en el índice de productores cuando el tamaño del grupo fue mayor, sin embargo, no se observó efecto en el número de presas .Este estudio destaca el potencial de investigar la búsqueda de alimento social en entornos controlados sin mucho espacio físico.

*Palabras clave*: modelo basado en agentes, unidades de alimento, tamaño del grupo, humano, juego del productor-aprovechador

Foraging behaviors are fundamental as they enable the survival of a species (Collier & Johnson, 2004). In individual foraging situations, resource acquisition depends on habitat characteristics and the individual's ability to accurately identify resource sources and assess potential gains compared to other available options within the habitat (Charnov, 1976; Pyke, 1984). However, in social foraging situations, resource acquisition also depends on the behavior of other group members, who can modify the availability and distribution of resources within the habitat (Beauchamp & Giraldeau, 1997) and share information about their location and accessibility (Bisbing et al., 2015; Kameda, & Nakanishi, 2002).

In social foraging situations within habitats composed of patch zones, where resources are available, and transition zones that physically separate the patch zones (e.g., Beauchamp & Giraldeau, 1997; Dumke et al., 2016; Hansen et al., 2016), It has been reported that group members tend to choose between one of two strategies: 1) actively engage in behaviors related to searching for patch zones (Producing), or 2) join a patch zone already discovered by another group member (Scrounging). The Producer-Scrounger Game (PSG) explores the optimal proportion of producers and scroungers within a group that reaches an Evolutionarily Stable Strategy (ESS), where the resources obtained through both strategies are approximately equal, ensuring the group's survival (Barnard & Sibly, 1981; Beauchamp, 2000). Additionally, it is assumed that the amount of resources obtained through a particular strategy depends on how frequently other group members adopt the same strategy. The scrounger strategy becomes less profitable than the producer strategy when most of the group employs the scrounger strategy, and vice versa (Mottley & Giraldeau, 2000).

Vickery et al.'s (1991) Rate-Maximization Model (RMM) has been one of the most widely used to estimate the proportion of producers (P^) that reach an Evolutionarily Stable Strategy based on group size (G), the number of resources in patch zones (F), and the finder's share (a), defined as the number of resources the producer consumes before a scrounger joins the patch (P^= a/F+1/G). From this model, at least two general predictions can be derived: 1) the proportion of producers will be lower in conditions where the group size is larger, in contrast to conditions where the group size is smaller. 2) The proportion of producers will be lower in conditions where the number of resources is higher compared to conditions where the number of resources is lower. These predictions have been tested across a range of species, including primates (Sacramento & Bicca-Marques, 2022), birds (Beauchamp & Giraldeau, 1997), rats (Alfaro & Cabrera, 2021; Avila-Chauvet et al., 2024a), fishes (Avila-Chauvet et el., 2024b; Hansen et al., 2016), spiders (Dumke et al., 2016), among others. However, the proportion of studies involving human participants remains low despite the potential applications in fields such as education and politics (Vickery, 2013; Wells, 2023).

In contrast to the experimental setups typically employed with non-human animals, where individuals search for resources in holes distributed across a foraging platform (e.g., Alfaro & Cabrera, 2021; Beauchamp & Giraldeau, 1997), the setups used with human participants tend to be more diverse (Avila-Chauvet et al., 2023). On the one hand, there are *Indirect Interaction Tasks* in which participants, after choosing a strategy, receive feedback on the gains or choices of other participants without directly observing their behavior. For example, (a) the participants can choose between designing their arrows (produce) or copying the arrow designs of other participants (scrounge) to capture the largest number of prey in a simulated hunting scenario (Mesoudi, 2008); or (b) participants can choose between paying to search for treasures in a 5×5 matrix (produce) or waiting for others to uncover treasures and taking a portion of the discovered treasures (scrounge) (Kim et al., 2019). On the other hand, there are *Direct Interaction Tasks* in which participants engage in real-time interactions with other group members and observe their behavior continuously. For example, recently, Ávila-Chauvet et al. (2023) and Deffner et al. (2024) proposed tasks based on three-dimensional games in which groups of four participants can move freely within the habitat and search for resources buried in patch zones (produce) or join a previously discovered patch zone (scrounge). As common features, these tasks follow a similar approach to those used in other species and incorporate several components of a foraging episode, including search, identification, selection, consumption, and handling. However, they differ in how resources emerge from the patch zones. In the Ávila-Chauvet et al. (2023) task, patch zones remain static, and the total programmed number of resources appears once a patch zone is discovered. While in the task of Deffner et al. (2024), patches are randomly distributed, and resources emerge sequentially at a constant rate.

One of the key requirements for implementing these tasks is to ensure appropriate experimental conditions, including sufficient equipment and adequate physical space to accommodate four participants. It is also important to consider that experimental sessions may occasionally be canceled if a participant fails to attend or voluntarily decides to withdraw from the experiment. Furthermore, in light of the recent experience with the COVID-19 health contingency, the development of tasks that minimize physical interaction between participants have become increasingly relevant (Lourenco & Tasimi, 2020). Alternatively, we propose a new *Direct Interaction Task* to study the PSG in human participants using an agent-based model (ABM) approach (Dubois et al., 2012). This online behavioral task is designed for a single participant to interact with virtual agents. This represents an advantage for studying the effect of group size without requiring larger physical spaces, which has not yet been explored with this type of task. Two key RMM model predictions were tested to assess the task's validity: (a) the proportion of producers will decrease as group size increases; (b) the proportion of producers will decrease as the number of resources increases.

## Method

### Participants

Eighty participants, aged 17 to 30, from a public university in Guadalajara, Mexico, participated in the study (male: $n = 32$; female: $n = 48$; Age: $M = 23.08$, $SD = 12.61$). The Review Board of the Center approved the research protocol for Studies and Research in Behavior. Participants were provided with an informed consent document, which explained the study's objectives, procedures, and the exclusive use of personal information for research purposes.

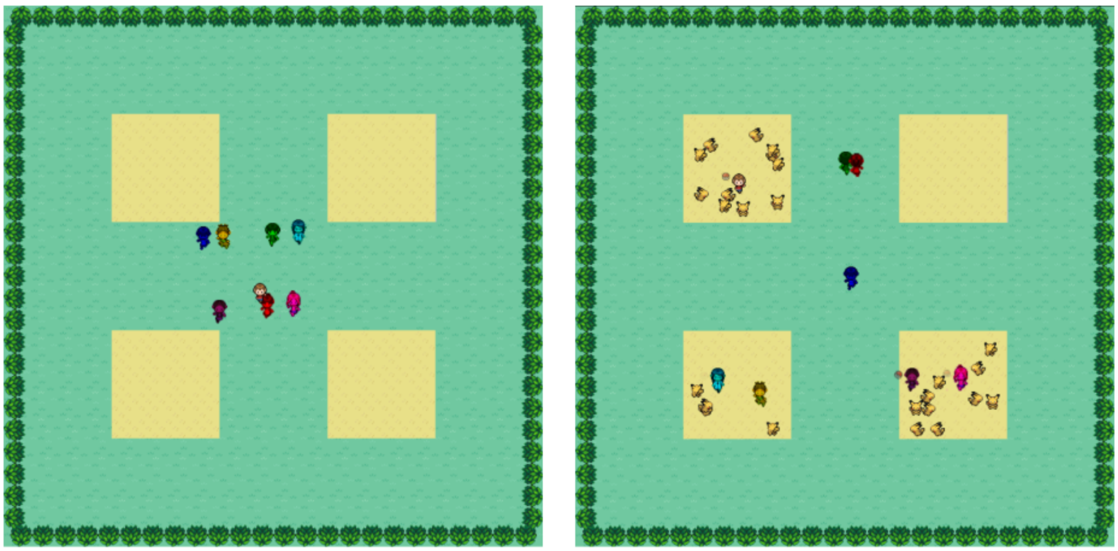
### Online Guaymas Foraging Task

An HTML version of the Guaymas Foraging Task (Ávila-Chauvet et al., 2023; Elenes-Rivera et al., 2024) for a single participant was developed for web browsers. This task uses an approach similar to those applied in other species to study the PSG (e.g., Alfaro & Cabrera, 2021; Avila-Chauvet et al., 2024a) and incorporates key processes of a foraging episode.

Participants could freely move an agent (25×25px) using the arrow keys within a virtual habitat (640×640px), which contained four patch zones (128×128px) positioned near each corner of the habitat (Figure 1). At the beginning of the task, the participant's agent and the ABM agents were positioned at the center of the habitat. Subsequently, during the task, participants could: (a) initiate search: navigate the habitat at 10 pixels per tenth of a second, seeking out patch zones; (b) identification: observe the availability of patch zones or the prey produced by other ABM agents; (c) choice: choose between excavating a patch zone by holding the spacebar for two seconds to make prey appear with a λ probability of 0.2 (produce) or joining a previously discovered patch zone (scrounge); (d) consume: collide with prey to obtain it; and (e) handling: during this time, the agent remained immobile for two seconds.

**Figure 1**

*Screenshot of the Online Guaymas Foraging Task*

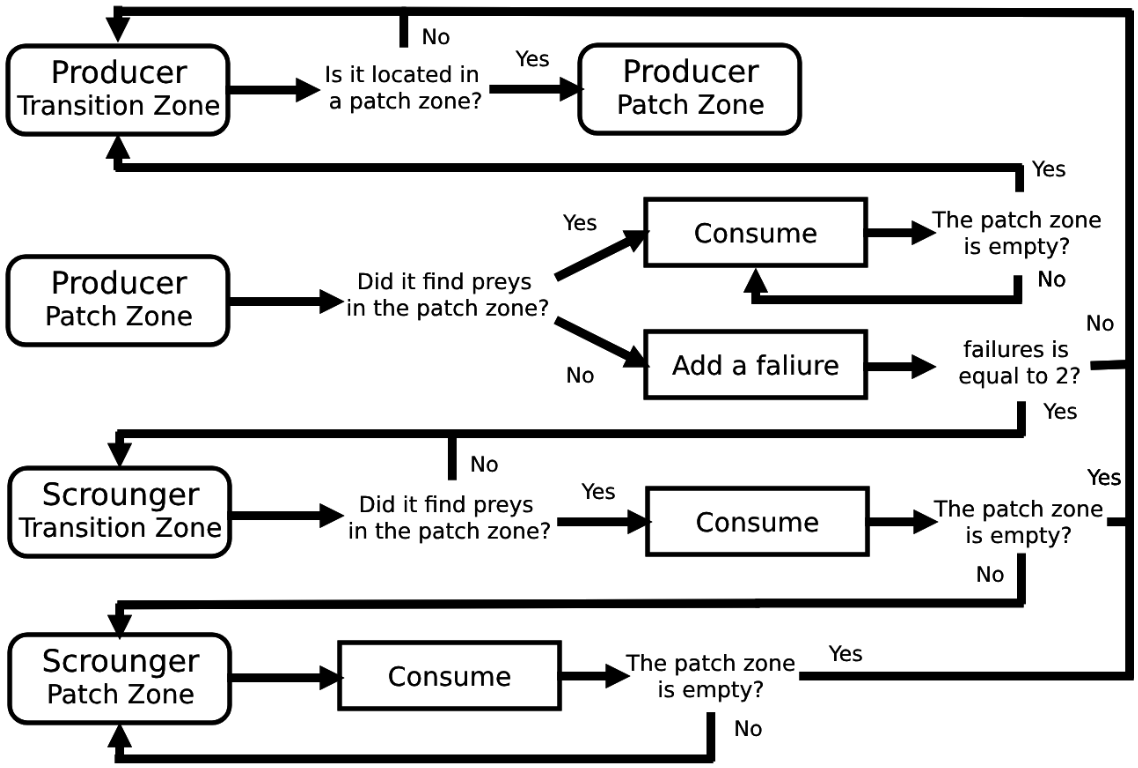


**Agent's Behavior**

Participants competed for resources against ABM agents based on the model proposed by Dubois et al. (2012), which is consistent with the predictions of the RMM. The ABM agents operated under the same rules (Figure 2) and could be in one of the following states: (a) Producer Transition Zone (PTZ): moves directly toward a randomly chosen patch zone. If the selected patch zone is occupied, the ABM agent chooses a new one; (b) Producer Patch Zone (PPZ): the agent simulates a two-second spacebar press. If prey appears, the agent initiates consumption, prioritizing the nearest prey. If no prey appears, the agent accumulates a failure. When two or more failures are accumulated, the agent shifts to the STZ state; (c) Scrounger Transition Zone (STZ): the agent moves directly toward the nearest prey in a previously discovered patch zone. If no patch zone has been discovered, the agent shifts to the PTZ state; and (d) Scrounger Patch Zone (SPZ): the agent consumes the available prey within the patch zone. Once all prey items are depleted, the agent leaves the patch zone and shifts to PTZ.

**Figure 2**

*ABM Agent Behavior Rules Flowchart*




**Procedure**

The eighty participants were divided into groups of twenty and randomly assigned to one of four conditions, which varied the number of prey within the patch zones (F = 5, F = 15) and the group size (G = 4, G = 8). The researcher read the informed consent document, and participants were informed that those who captured the highest number of prey would receive a compensation of one Mexican peso per prey captured. Before starting the experimental condition, which lasted five minutes, participants underwent an individual training phase in which they were required to search for prey in the patch zones at least five times.

**Data Analysis**

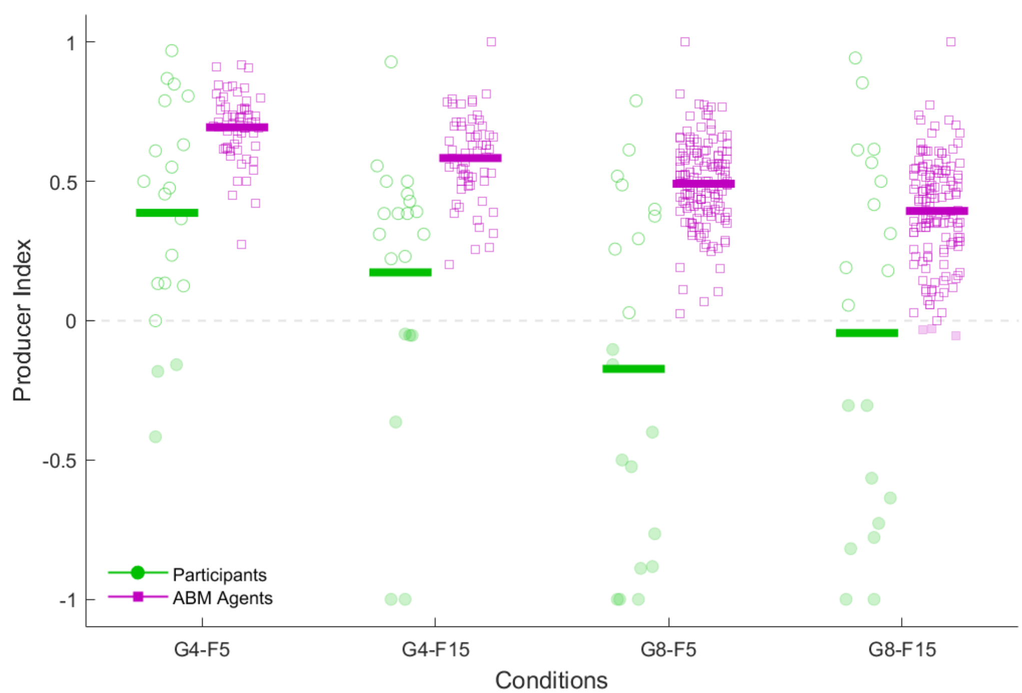
We defined a producer response ($R^P$) as searching within a patch zone, while we defined a scrounger response ($R^S$) as joining a previously exploited patch zone. We calculated the Producer Index (Harten et al., 2018) based on these responses ($[R^P-R^S]/[R^P+R^S]$). Values close to 1 indicate a tendency to produce, while values close to -1 suggest a tendency to scrounge. To compare the producer index, the number of prey, and the finder's share, we conducted two-way ANOVAs with group size and number of prey as factors. Statistical analyses were performed using the open-access software JASP, version 18.0.0 (JASP Team, 2025).

## Results

Regarding participants' age, no significant differences were found across the four groups. An ANOVA indicated no significant differences in age between groups ($F(3, 75) = 0.57$, $p = .634$). The predictions of the RMM model (Vickery et al., 1991) suggest that the proportion of producers will decrease as group size or the number of resources increases. Figure 3 shows the participant's producer index. The producer index was lower when the group size was eight (G8-F5: $M = -0.17$, $SD = 0.61$; G8-F15: $M = -0.04$, $SD = 0.64$) compared to groups of four (G4-F5: $M = 0.38$, $SD = 0.39$; G4-F15: $M = 0.17$, $SD = 0.48$). However, no systematic effect of the number of prey was observed. A two-way ANOVA revealed no interaction effect between group size and the number of prey ($F(1,72) = 1.97$, $p = .165$, $\omega^2 = 0.011$). However, a main effect was observed for group size ($F(1,72) = 10.17$, $p = .002$, $\omega^2 = 0.103$). However, not for the number of prey($F(1,72) = 0.12$, $p = .72$, $\omega^2= 0.000$). For the ABM agents, the producer index was lower when the group size was eight (G8-F5: $M = 0.49$, $SD = 0.15$; G8-F15: $M = 0.39$, $SD = 0.19$) compared to a group size of four (G4-F5: $M = 0.69$, $SD = 0.12$; G4-F15: $M = 0.58$, $SD = 0.15$), and when the number of prey was 15 compared to five. A two-way ANOVA revealed no interaction effect between group size and the number of prey ($F(1,396) = 0.11$, $p = .731$, $\omega^2 = 0.000$). However, a significant main effect was observed for group size ($F(1,396) = 117.71$, $p < .001$, $\omega^2 = 0.211$) and the number of prey ($F(1,396) = 33.12$, $p < .001$, $\omega^2 = 0.058$).

**Figure 3**

*Producer Index of Participants and ABM Agents for Each Condition*



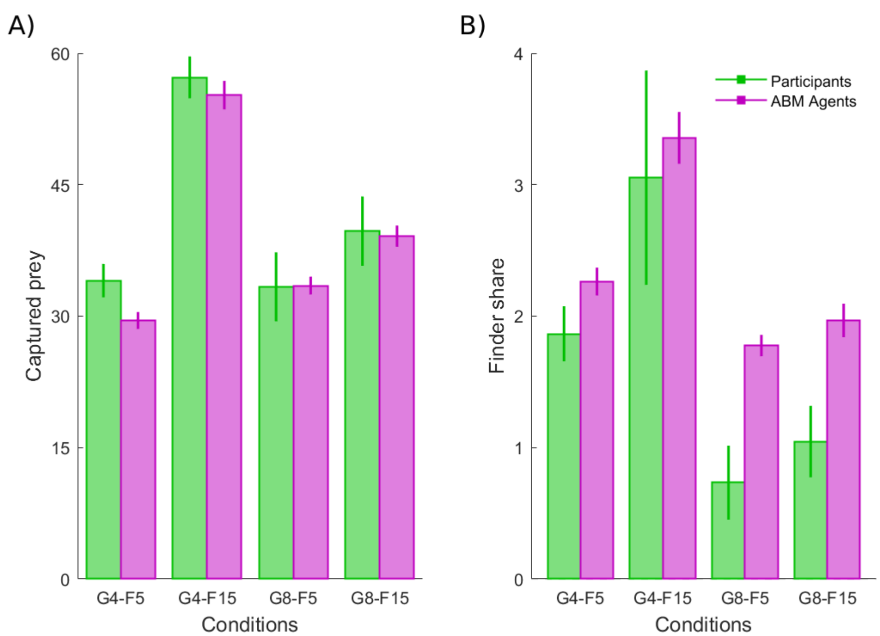

*Note.* Each condition varies by group size (G) and number of prey (F). Circles represent participants, squares represent ABM agents, and the line indicates the average for each group.

Figure 4A shows the total prey captured by participants and ABM agents. As expected, participants captured more prey in conditions with 15 programmed prey (G4-F15: $M = 57.2$, $SD = 10.6$; G8-F15: $M = 39.7$, $SD = 17.5$) than in conditions with five programmed prey (G4-F5: $M = 34.0$, $SD = 8.5$; G8-F5: $M = 33.3$, $SD = 17.5$). Furthermore, the number of prey captured was slightly lower in conditions where the group size was eight. A two-way ANOVA revealed an interaction effect ($F(1,76) = 7.12$, $p = .010$, $\omega^2 = 0.053$) as well as significant main effects for group size ($F(1,76) = 8.23$, $p = .005$, $\omega^2 = 0.064$) and the number of prey ($F(1,76) = 21.60$, $p < .001$, $\omega^2 = 0.181$). For the ABM agents, it was observed that more prey was captured in conditions with 15 programmed prey (G4-F15: $M = 55.21$, $SD = 12.5$; G8-F15: $M = 39.1$, $SD = 14.2$) compared to conditions with five programmed prey (G4-F5: $M = 29.0$, $SD = 7.4$; G8-F5: $M = 33.4$, $SD = 12.0$). Two-way ANOVA revealed an interaction effect ($F(1,396) = 54.63$, $p < .001$, $\omega^2 = 0.096$) as well as significant main effects for group size ($F(1,396) = 19.85$, $p < .001$, $\omega^2 = 0.034$) and the number of prey ($F(1,396) = 133.33$, $p < .001$, $\omega^2 = 0.096$).

Figure 4B shows the finder's share, or the number of prey the producer consumes before a scrounger joins the patch. For participants, the finder's share was lower when the number of prey was five (G4-F5: $M = 1.8$, $SD = .93$; G8-F5: $M = 0.73$, $SD = 1.2$) compared to 15 (G4-F15: $M = 3.5$, $SD = 3.6$; G8-F15: $M = 1.0$, $SD = 1.2$). A two-way ANOVA revealed only significant main effects on group size ($F(1,72) = 11.41$, $p = .001$, $\omega^2 = 0.11$). For agents, the finder's share was lower when the number of prey was five (G4-F5: $M = 2.2$, $SD = .81$; G8-F5: $M = 1.7$, $SD = 0.95$) compared to 15 (G4-F15: $M = 3.5$, $SD = 1.5$; G8-F15: $M = 1.9$, $SD = 1.5$). Two-way ANOVA revealed an interaction effect ($F(1,396) = 9.71$, $p = .002$, $\omega^2 = 0.023$) as well as significant main effects for group size ($F(1,396) = 42.04$, $p < .001$, $\omega^2 = 0.106$) and the number of prey ($F(1,396) = 19.69$, $p < .001$, $\omega^2 = .048$).

**Figure 4**

*Captured Prey and Finder's Share of Participants and ABM Agents for Each Condition*




*Note.* Figure 4A shows the average number of prey captured by participants and ABM agents. Figure 4B presents the finder's share, or the number of prey the producer consumes before a scrounger joins the patch zone.

## Discussion

The Direct Interaction Tasks simulate several behaviors involved in a foraging episode and allow participants to interact with other group members similarly to those observed in studies with non-human species. However, it is important to consider that the implementation requires sufficient equipment and adequate physical space for all participants (Ávila-Chauvet et al., 2023; Deffner et al., 2024), which can become problematic during health contingencies or when experiments require large group sizes. As an alternative, a web browser-compatible task for a single participant was developed, in which the participant competes for resources against agents modeled on the ABM proposed by Dubois et al. (2012).

To validate this task, two key predictions of the RMM model were examined. The first prediction states that the proportion of producers will decrease as group size increases. The results show that the producer index was lower in groups of eight than four. This pattern was consistently observed in participants and ABM agents. As in other species where individuals are required to move within the habitat or foraging platforms to produce or scrounge resources (e.g., Alfaro & Cabrera, 2021; Hansen et al., 2016), this pattern was consistently observed in participants and ABM agents. As expected, the finder's share was lower in conditions with larger group sizes. When the finder's share is lower, the proportion of producers decreases, a pattern corroborated in other species (Sacramento & Bicca-Marques, 2022) and agent-based models (Afshar & Giraldeau, 2014). In this task, characterized by a confined space with a fixed number of patch zones, an increase in group size reduces the distance between members, thereby decreasing the time it takes for scroungers to join a patch zone. The supplementary materials can provide more detailed information regarding the distance between agents.

Regarding the second prediction, which states that the proportion of producers decreases as the number of resources increases, the participants' results did not align with the predictions of the RMM or with observations in other species (Dumke et al., 2016; Hansen et al., 2016). On the other hand, as anticipated, the effect of the number of resources was observed in the ABM agents, consistent with the ABM proposed by Dubois et al. (2012). Despite participants and ABM agents capturing similar amounts of prey in most conditions, the finder's share of the participants tends to be lower than that of the ABM agents. One possible explanation is that the agents exhibited more efficient behavior compared to the participants, as their actions were triggered by habitat events and not influenced by individual characteristics or decision-making processes (Ávila-Chauvet et al., 2023; Kim et al., 2019; Reichert et al., 2021; Roncoroni et al., 2024). This disadvantage for participants may have impacted their finder's share, reducing the producer's responses, particularly in conditions with fewer resources. In the future, random waiting times before each action will be implemented to mitigate this disadvantage.

In conclusion, an online task for a single participant was developed to study the PSG, utilizing agents modeled on the ABM of Dubois et al. (2012). Although the effect of the number of resources in the patch zones was not observed, the effect of group size was present, as seen in other species (e.g., Dumke et al., 2016; Hansen et al., 2016). To our knowledge, this is the first time this effect has been reported in humans using a Direct Interaction Task. As participants competed against agents, large physical spaces were not required. Nevertheless, this study presents notable limitations, including a small sample size and using ABM agents with stable behavior. Future research aims to explore various ABMs, incorporating learning rules that enable greater phenotypic variation in the agents due to their experience with the outcomes of each strategy (Afshar & Giraldeau, 2014; McNamara et al., 2024). These modifications are expected to simulate better the effects on behavioral variability resulting from introducing a mutant strategy, such as that of the participant (Beauchamp, 2000). Finally, it is important to highlight the potential of this task as an alternative or complementary approach to self-reports for assessing behaviors associated with exploitation or theft (Salekin et al., 1996). Since it can be easily implemented and is designed for a single participant, it could be used in contexts related to learning (Vickery, 2013), public policy (Wells, 2023), or substance use disorders (Ávila-Chauvet et al., 2023).

## References


Afshar, M., & Giraldeau, L. A. (2014). A unified modelling approach for producer–scrounger games in complex ecological conditions. *Animal Behaviour, 96*(2014), 167–176. https://doi.org/10.1016/J.ANBEHAV.2014.07.022

Alfaro, L., & Cabrera, R. (2021). Effect of group size on producer–scrounger strategies of Wistar rats. *Behavioural Processes, 182* (2021), 104280. https://doi.org/10.1016/J.BEPROC.2020.104280

Avila-Chauvet, L., Aguilar, Y. L. O., García-Leal, O., Cruz, D. M., & Esparza, C. (2024a). Social foraging and time of access to patch zones in rats. *Mexican Journal of Behavior Analysis, 50*(1). https://doi.org/10.5514/rmac.v50.i1.88700

Avila-Chauvet, L., Cruz, D. M., García-Leal, Ó., & Kluwe-Schiavon, B. (2023). To produce or not to produce? Contrasting the effect of substance abuse in social decision-making situations. *Heliyon, 9*(9), e19714. https://doi.org/10.1016/J.HELIYON.2023.E19714

Avila-Chauvet, L., Elenes-Rivera, J., Cruz, D. M., & Ojeda Aguilar, Y. L. (2024b). Effect of resource-associated signals on producer responses: Insights from golden fish (*Carassius auratus*) and an agent-based model. *Journal of Comparative Psychology*. Advance online publication. https://doi.org/10.1037/com0000400

Barnard, C. J., & Sibly, R. M. (1981). Producers and scroungers: A general model and its application to captive flocks of house sparrows. *Animal Behaviour, 29*(2)*,* 543–550. https://doi.org/10.1016/S0003-3472(81)80117-0

Beauchamp, G. (2000). Learning rules for social foragers: Implications for the producer–scrounger game and ideal free distribution theory. . *Journal of Theoretical Biology, 207*(1)*,* 21–35. https://doi.org/10.1006/JTBI.2000.2153

Collier, G., & Johnson, D. F. (2004). The paradox of satiation. Physiology & Behavior, *82*(1), 149–153. https://doi.org/10.1016/J.PHYSBEH.2004.04.041

Charnov, E. L. (1976). Optimal foraging, the marginal value theorem. *Theoretical Population Biology, 9*(2), 129–136. https://doi.org/10.1016/0040-5809(76)90040-X

Deffner, D., Mezey, D., Kahl, B., Schakowski, A., Romanczuk, P., Wu, C. M., & Kurvers, R. H. (2024). Collective incentives reduce over-exploitation of social information in unconstrained human groups. *Nature Communications*, *15*(1), 2683. https://doi.org/10.1038/s41467-024-47010-3

Dubois, F., Giraldeau, L. A., & Réale, D. (2012). Frequency-dependent payoffs and sequential decision-making favour consistent tactic use. P*roceedings of the Royal Society B: Biological Sciences, 279*(1735), 1977–1985. https://doi.org/10.1098/RSPB.2011.2342

Dumke, M., Herberstein, M. E., & Schneider, J. M. (2016). Producers and scroungers: Feeding-type composition changes with group size in a socially foraging spider. *Proceedings of the Royal Society B: Biological Sciences, 283*(1828)*.* https://doi.org/10.1098/RSPB.2016.0114

Elenes-Rivera, J. A., Avila-Chauvet, L., & Mejía-Cruz, D. (2024). Efecto de la ganancia de información en situaciones de forrajeo social en humanos. *Psicumex, 14*(2014). https://doi.org/10.36793/psicumex.v14i1.606

Hansen, M. J., Ward, A. J. W., Fürtbauer, I., & King, A. J. (2016). Environmental quality determines finder-joiner dynamics in socially foraging three-spined sticklebacks (*Gasterosteus aculeatus*). *Behavioral Ecology and Sociobiology, 70*(6), 889–899. https://doi.org/10.1007/S00265-016-2111-5/METRICS

JASP Team (2025). JASP (Version 0.18.0)[Computer software].

Kameda, T., & Nakanishi, D. (2002). Cost-benefit analysis of social/cultural learning in a nonstationary uncertain environment: An evolutionary simulation and an experiment with human subjects. *Evolution and Human Behavior, 23*(5)*,* 373–393. https://doi.org/10.1016/S1090-5138(02)00101-0

Kim, H. rin, Toyokawa, W., & Kameda, T. (2019). How do we decide when (not) to free-ride? Risk tolerance predicts behavioral plasticity in cooperation. *Evolution and Human Behavior, 40*(1), 55–64. https://doi.org/10.1016/J.EVOLHUMBEHAV.2018.08.001

Lourenco, S. F., & Tasimi, A. (2020). No participant left behind: Conducting science during COVID-19. *Trends in Cognitive Sciences, 24*(8), 583–584. https://doi.org/10.1016/j.tics.2020.05.003

McNamara, J. M., Dall, S. R., Houston, A. I., & Leimar, O. (2024). The evolutionary consequences of learning under competition. *Proceedings B, 291*(2028), 20241141. https://doi.org/10.1098/rspb.2024.1141

Mesoudi, A. (2008). An experimental simulation of the "copy-successful-individuals" cultural learning strategy: adaptive landscapes, producer–scrounger dynamics, and informational access costs. *Evolution and Human Behavior, 29*(5), 350–363. https://doi.org/10.1016/J.EVOLHUMBEHAV.2008.04.005

Mottley, K., & Giraldeau, L. A. (2000). Experimental evidence that group foragers can converge on predicted producer scrounger equilibria. *Animal Behaviour*, *60*(3), 341–350. https://doi.org/10.1006/anbe.2000.1474

Pyke, G. H. (1984). Optimal foraging theory: A critical review. Annual Review of Ecology, Evolution, and Systematics, *15*, 523–575. https://doi.org/10.1146/annurev.ecolsys.15.1.523

Reichert, M. S., Morand‐Ferron, J., Kulahci, I. G., Firth, J. A., Davidson, G. L., Crofts, S. J., & Quinn, J. L. (2021). Cognition and covariance in the producer–scrounger game. *Journal of Animal Ecology, 90*(11)*,* 2497–2509. https://doi.org/10.1111/1365-2656.13551

Roncoroni, A., Ersoy, S., & Bijleveld, A. I. (2024). Slow-exploring captive red knots were quicker to find food in a social setting than fast explorers. *Biology Letters, 20*(7), 20240139. https://doi.org/10.1098/rsbl.2024.0139

Sacramento, T. S., & Bicca-Marques, J. C. (2022). Scrounging marmosets eat more when the finder's share is low without changing their searching effort. *Animal Behaviour, 183*(2022), 117–125. https://doi.org/10.1016/J.ANBEHAV.2021.11.003

Salekin, R. T., Rogers, R., & Sewell, K. W. (1996). A review and meta-analysis of the Psychopathy Checklist and Psychopathy Checklist—Revised: Predictive validity of dangerousness*. Clinical psychology: Science and Practice*, *3*(3), 203. https://doi.org/10.1111/j.1468-2850.1996.tb00071.x

Vickery, W. L., Giraldeau, L. A., Templeton, J. J., Kramer, D. L., & Chapman, C. A. (1991). Producers, scroungers, and group foraging. *The American Naturalist, 137*(6), 847–863. https://doi.org/10.1086/285197

Vickery, W. L. (2013). Producing and scrounging during Problem-Based Learning. *Journal of Problem Based Learning in Higher Education, 1*(1)*,* 36–52. https://doi.org/10.5278/OJS.JPBLHE.V1I1.272

Wells, J. C. K. (2023). An evolutionary perspective on social inequality and health disparities Insights from the producer-scrounger game. *Evolution, Medicine, and Public Health,* 11(1), 294–308. https://doi.org/10.1093/emph/eoad026

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