Optimal Foraging Theory: Enhancing Student Understanding Through Role Play and Strategy Gaming

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Abstract: The use of interactive role playing games is shown to benefit both student experience as well as their depth of understanding and ability to apply specific principles. With this in mind, a game was developed to improve student awareness of optimal foraging theory within the behavioral ecology module of a bachelor's degree. The basic structure of the game addressed the major principles existing within scientific research to date and allowed students to generate their own "foraging entities." The game itself was followed by an informal feedback session, during which the students were asked to critique their adopted strategies relative to their success, or lack thereof, within the game. Student responses were found to fit well within experimental models of optimal foraging theory.

Keywords: optimal foraging theory (OFT), behavioral ecology

Introduction

Role-playing can be defined as a game or activity which allows participants to actively immerse themselves within a learning environment through the assumption of a character (Feinstein et al., 2002). Although, in this case, a rudimentary understanding of Optimal Foraging Theory (OFT) is an important basis for successful role-play learning, loose application of rules allows players to respond to cues given by others within the game. Role-playing also identifies misconceptions or increases meaningful dialogue between participants (McDonald and Hannafin, 2003). Such learning tools are systematically applied to action learning (Zuber-Skerritt, 2001) and business theory (Zgodavová et al., 2001), but are rarely, if ever, applied to disciplines within the biological sciences. Previous exploration of role-play and strategy learning has been relative to the creation of computer and mathematical simulations, rather than situations into which the player is physically co-opted. In reference to the former, research suggests both an increase in student motivation and desire to learn through increased engagement (Vogel et al., 2006). These findings may still be pertinent if applied to the latter.

Often, within science, student engagement with pure theory may be greeted with disinterest by those who find the topic difficult or, likewise, by those for whom theoretical concepts are unchallenging. However, role-playing serves to give the student an experiential perspective, supported by the direct application of previously imparted research and theory, rather than a passive knowledge based on traditional teaching methods. Such immersion tactics may not only address what is learned but how, allowing students to build upon what they already understand through creative role-play as part of an interactive learning environment (Hackbarth, 1996). OFT is commonly used to explain nutritive choices made by animals, both spatially (Marion et al., 2005), and temporally (Hills and Adler, 2002). Many of these choices can be predicted and are based on simple models of cost benefit analysis, where the energetic value of a particular foraging event must outweigh the concurrent risk of predation (Arcis and Desor, 2003; Winterrowd and Devenport, 2004). However, other costs must also be considered, including the quality of the foraging area, or "patch," in terms of food abundance, or cues which may be indicative thereof (Butler et al., 2005), and the travel time and distance between suitable feeding sites (Genaro and Schmidek, 2000). OFT may also be facilitated (by reducing predation risk) or hindered (by increasing rate of patch depletion) by the presence of conspecifics. In such cases, further tradeoffs emerge between group versus solitary foraging strategies (Giraldeau and Beauchamp, 1999). Finally, as with any finite resource there will be a cost of defense which must be considered, and this will also impact directly on the cost benefit analysis of a particular nutritional choice. In addition, any and all of these considerations must account for future benefits to the group or individual versus immediate costs relative to time and energy (Heinsohn, 1997).

OFT can therefore be identified as consisting of several interlocked components, each of which has an effect on whether or not an individual functions optimally. Although the interaction may appear complex, simple rules, combined synergistically with the flexibility of role-play gaming, may allow greater understanding of the underlying principles.

Methods

Before the beginning of the game students are asked to pick roles based on their own knowledge of OFT and predictions as to which strategy may best serve their goals as "foraging entities." The role falls into one of six categories, although players are allowed to develop their strategy and alter roles as the game progresses. The categories are:

- Sharing: Individuals show a greater propensity for group foraging and sharing of patch resources.
- Lone forager: Individuals are unlikely to share a patch and are more likely to desert or defend than share resources.
- Risk taker: Individuals are more likely to risk predation if returns are great.
- Selective forager: Individuals will reject low quality forage and are more likely to forage alone or in small groups. In this case individuals may collect one more forage item than others and all items with a value less than five must be returned.
- Patch faithful: Individuals are less likely to move between patches.
- Defender: Individuals are liable to forage alone and will aggressively defend their patch against intruders even if out-numbered.

Although these roles appear prescriptive the degree to which students are able to alter or negotiate their role is dependent on the evolution of the game. Roles may also be added or deleted relative to the desired outcome for the tutor.

In accordance with OFT, patches of variable quality must be provided, allowing students the opportunity to forage. The easiest method is through the use of ballot boxes which allow physical access but not visual assessment. Approximately one per three students is ideal. The forage items are represented by printed numbers ranging from one to ten, where ten is the highest value item. The total number of items and the range of values should differ between ballot boxes, but for a 30 minute tutorial a minimum of 50 forage items per patch is recommended.

All students begin the game at a central patch from which they are able to disperse at will. A foraging event occurs that lasts a set, or standard amount of time, with 30 seconds often being appropriate. During a single foraging event, students may take one or more items from the ballot box. The number of items taken will depend on the number of individuals engaged at any one site: Lone foragers receive three items; groups of two receive two items each and groups of three or more only one item per student.

Each ballot box will also carry a number that is either one, two or three times the duration of the event (e.g., for a 30s interval it will read 30s, 1min, 1min30s). This represents the time cost associated with traveling between patches and should therefore affect the readiness of a student to desert their current patch. On arrival, for whatever reason, the time on the box represents how long the player must wait before being able to recommence foraging.

In addition some boxes carry a "danger" sign. These represent patches where the risk of predation is relatively great. Predation events are dictated by the tutor and occur once after every two foraging events. At this point the tutor randomly selects from the students a single individual who receives a penalty as outlined below. It is important that two of every three predation events should target either single foragers, or those at the danger areas. This represents greater risks associated with certain patches or with lone foraging and is not communicated to the students prior to the beginning of the game. As removal from the game following predation is counterproductive for student learning, a penalty is imposed for each student "predated." This may be either a time penalty of one minute during which the student cannot forage, or the removal of a pre-established value of foraged items, a value of 20-30 is suitable.

Finally, as patches are encroached upon by others within the game, the resident (the first student at the patch) may choose to desert the patch, to accept the intruder or repel the intruder. This will depend on his/her chosen strategy, but also on the perceived resource value. Defense itself carries a time penalty of one foraging event for both or all participants and the loser must immediately vacate the patch. The dispute is decided through the traditional "rock, paper, scissors" game and is the best of three. In the case of a group attack on the territory the defender will automatically be displaced if he/she does not wish to join the group.

At the end of the game all players must reach a composite score for the tutorial. This is done by adding the value of all foraged items, which should carry a number from one to ten. Students should then tally the number of times they were predated, if predation carried a pre-established penalty (e.g. minus 20) they should then remove this from their overall score. If the predation penalty was associated with a loss of foraging time it should be noted and brought into the discussion relative to the strategy adopted. The game is then followed by a discussion based on each individual's strategy and whether or not it was successful, the discussion should start with each student announcing their composite score, number of predation events, the strategy they selected and if or how their strategy developed during the tutorial. The tutor should allow free discussion to a point, but also be prepared to direct the students towards conclusions they may not have fully explored. The tutorial will allow each student to assess the role he/she played and how it did or did not fit within the boundaries of OFT. One of the more interesting points within the discussion is that success may often depend on both the individual strategy and those employed by the other players. As such, if played in a "free choice" format, results will differ for each cohort of students and will allow greater immersion into the variability that is prevalent within natural systems of behavioral ecology.

Discussion

Active participation by students through the development of games not only helps increase understanding, but allows the students themselves to generate an active body of knowledge around the subject, as opposed to the traditional passive transfer of pre-established theory. Informal feedback from 50 participants suggests that, for the majority, the experience was well received and improved understanding of the underlying principles involved in OFT. Brief written statements from the students following the game supported its use in future years and in one case even suggested "I would feel far more confident in answering a question on OFT in the final exam, can we have one please". In addition, the exercise was found to improve participation and interaction between members of the class as well as generating free discussion. Although the event was not formally assessed, future comparisons between cohorts who have played the game, relative to those who have not, may reveal interesting differences in learning and examination success.

Responses during feedback often supported the findings of research, including principles such as: movement associated with food density (Butler et al., 2005), remaining patch faithful when success is high (Bradshaw et al., 2004) and modifying behavior relative to perceived predation risk (Powell and Banks, 2003). Sharing of resources was found to be of overall benefit to the group whilst providing advantages (e.g. reduced predation, moderate intake) to each individual within the group (Mitani and Watts, 2001). In addition, those individuals that selected to defend resources found it to be a costly strategy in line with research findings (Chapman and Kramer, 1996).

As with any role-playing game the opportunity for refinement is ever present. Compared with the ever changing face of behavioral research this may be considered one of the strengths of any such teaching strategy. It is possible that such a framework could similarly be applied to the principles of hierarchical structures and breeding strategies.

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