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Human strategies for solving a time-place learning task: The role of counting and following verbal cues

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ABSTRACT

Two experiments were conducted to assess the emergence of time-place learning in humans. In experiment 1, a computer based software was designed in which participants had to choose to enter one of four rooms in an abandoned house search for a zombie every 3–15 s. Zombies could be found in only one of these rooms every trial in 3 min periods during the 12 min sessions. After 4 training sessions, participants were exposed to a probe session in which zombies could be found in any room on every trial. Almost all participants behaved as if they were timing the availability intervals: they anticipated the changes in the location of the zombie and they persisted in their performance patterns during the probe session; however, verbal reports revealed that they were counting the number of trials in each period in order to decide when to switch between rooms. In the second experiment, the task was modified in two ways: counting was made harder by using three different intertrial ranges within each session: 2–6 s, 2–11 s and 2–16 s. Second, labels were displaced during the final session to assess whether participants learned to click on a given place or to follow a set of verbal cues. We found that participants did not notice the label changes suggesting that they learned to click on a given place, and that a win/stay–lose/shift strategy was clearly used to decide when to switch rooms in the second experiment. The implications of verbal behavior when assessing time-place learning with humans and the possible differences in this process between humans and animals are discussed.

1. Introduction

Time-place Learning (TPL) has been said to be the ability to find and obtain resources with a spatiotemporally limited and predictable availability (Biebach et al., 1989; Wilkie and Wilson, 1992; Thorpe et al., 2007). A wide variety of species including fish (Reebs, 1993, 1996, 1999; Delicio and Barreto, 2008), rats (Carr and Wilkie, 1997, 1998, 1999; Widman et al., 2000), ants (Schatz et al., 1994) garden warblers (Krebs and Biebach, 1989; Biebach et al., 1991, 1994), pigeons (Wilkie and Wilson, 1992; Saksida and Wilkie, 1994; Wilkie et al., 1994), and other birds (Falk et al., 1992), have been shown to display TPL under many different circumstances.

A TPL task is defined by two key features: There must be more than one place where any given resource can be available, and the correct place (i.e., the one where the resource can be found) changes according to a temporal criterion. Crystal (2009) and Thorpe and Wilkie (2005) distinguished two different kinds of TPL tasks: (a) Daily TPL, where the correct place changes according to the time of day (e.g., Biebach, et al., 1989; Carr and Wilkie, 1997; Pizzo and Crystal, 2002), (b) interval TPL, where changes are scheduled within minutes or seconds since the start of an experimental session (Carr et al., 2001; Crystal and Miller, 2002; Pizzo and Crystal, 2004). A possible strategy to solve these tasks could be to respond on any given option until no more food is available in that option (i.e., a win/stay–lose/shift strategy). However, a widely accepted view of these types of TPL is that daily TPL is solved by using an endogenous circadian mechanism (Biebach et al., 1989, 1994; Widman et al., 2004; Deibel and Thorpe, 2013) and that animals solving an interval TPL task rely on an interval-timing mechanism with functions that resemble a stopwatch (Crystal and Miller, 2002; Thorpe et al., 2002; Thorpe and Wilkie, 2002; Pizzo and Crystal, 2004).

The study presented in this paper is concerned with interval TPL, which is thought to be critical from an evolutionary standpoint, because the ability of many different species to adjust their behavior to sudden and brief changes in the spatiotemporal availability of food could be extremely important to the survival of any

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given individual in natural conditions (Staddon, 1983; Thorpe and Wilkie, 2005).

Three common findings have usually been considered as evidence that animals exposed to an interval TPL task do not rely on a win/stay–lose shift strategy, and are rather, effectively timing the intervals involved (Thorpe and Wilkie, 2005; Thorpe et al., 2007):

A. Anticipation – Subjects start responding on any given option, with the obvious exception of the first one, just before it becomes the temporally correct one, suggesting that they are keeping track of time.
B. Anticipation of depletion – The temporal distribution of response during availability periods describes an ascendant–descendent function that sometimes has a peak (Wilkie and Willson, 1992; Wilkie et al., 1994; Carr et al., 2001), and others has a plateau (Thorpe et al., 2002, 2007; Pizzo and Crystal, 2002; Thorpe and Wilkie, 2005) that starts around the middle of the period and the descendent fraction at the end of it. This suggest that these organisms are sensitive to the time they have been responding in a given option, and thus, anticipate that food is about to run-out in that location.
C. Persistence of patterns – When faced with probe sessions, in which food can be obtained in any place at any time (open Hopper tests), subjects tend to maintain their visiting patterns, suggesting that some track of time is being carried out and not only a win/stay–lose/shift strategy.

Research about interval TPL has been primarily concerned with elucidating the possible timing mechanism involved in solving the task. In this regard, evidence has suggested the possibility of a stopwatch-like mechanism (Wilkie and Willson, 1992; Wilkie et al., 1994; Thorpe et al., 2007). Furthermore, the predictions derived from a prominent timing model, the scalar expectancy theory, (Gibbon, 1977) have been tested in this situations, and the data obtained do not fit to these predictions (Crystal and Miller, 2002; Thorpe and Wilkie, 2002).

Subjects are also said to be learning the association between places and feeding sites, rather than learning simple performance rules such as go-left, go-right, etc. (Wilkie et al., 1994; Pizzo and Crystal, 2004); however, this is far from conclusive, for there has been some evidence that rats are not able to solve the task when these involve complex sequences (Thorpe and Wilkie, 2006).

As it is often the case in the experimental analysis of behavior, there has been a growing interest in studying this process in humans, possibly due to the evolutionary importance often attributed to TPL. An example of a TPL study involving humans is that of Thorpe et al. (2012). They designed a TPL task for children using a touch screen and the drawing of a house featuring 3 different contiguous levels. Each room was used as an availability point in a TPL task that consisted of reinforcing touches on a room according to a variable ratio (VR) 6 schedule of reinforcement. The temporally correct room changed in a constant manner after 30 s. Thorpe et al. (2012) found that most of the children's responses were directed towards the temporally correct option; moreover, they found persistence of patterns in probe sessions in which reinforcements (the appearance of a toy in the screen) could be found in either room. Both of these findings suggest that their subjects relied on a TPL strategy. However, there are at least 3 features of Thorpe's study that deserve to be attended: (a) They admit that, even though unlikely, there is a possibility that their subjects relied on a counting strategy to decide when to switch rooms; (b) they failed to find both anticipation and anticipation of depletion, which are commonly thought to be evidence for timing on TPL Tasks; (c) the task itself, while based in widely used experimental paradigm for TPL research (Carr et al., 2001; Thorpe et al., 2002, 2005, 2007; Thorpe and Wilkie, 2005, 2006) entails little or no cost for wrong responses, thus encouraging switching randomly between rooms and precluding the emergence of a TPL strategy to solve the task.

Some limitations to the conclusions drawn by Thorpe et al. (2012) are imposed by those three features. Therefore, if human TPL is to be explored and understood, a different experimental approach could prove useful. First of all, it seems fairly straightforward that subjects should be asked to describe the strategy they used to solve the TPL task. This would allow knowing whether they were counting or not. On the other hand, Thorpe et al. (2012) used an experimental design based on a paradigm broadly used by Wilkie and his colleagues with pigeons and rats (Carr et al., 2001; Thorpe et al., 2002, 2005, 2007; Thorpe and Wilkie, 2005, 2006) which, in this particular case possesses the disadvantage of little (if any) cost for a wrong choice. One option to attend this issue is to design a task based on a discrete trial single choice arrangement like that of Biebach et al. (Biebach et al., 1989, 1991, 1994; Falk et al., 1992). Response cost in this particular arrangement could be seen as follows: this task would imply a limited amount of possible reinforcements, which would mean that a wrong choice does affect the final score the participant could obtain. Furthermore, the task described in the method section implies a competition arrangement: the highest ranked participant got a prize (a psychology book). A reasonable assumption is that these traits of the task could affect the participants' motivation level, increasing the cost of choosing to enter the wrong room and therefore the likelihood of finding TPL (Widman et al., 2000). Thereby, the purpose of the present study was to assess the effectiveness of a discrete trial single choice TPL task to explore interval time-place learning with humans.

2. Experiment 1

2.1. Material and methods

2.1.1. Participants

Six undergraduate students, 3 male and 3 female, from a Psychology course at the School of Superior Studies of the National Autonomous University of México (UNAM, for the Spanish Acronym). Subjects were 18 years old in average. All of them were recruited as volunteers, they were told to be participating in a learning experiment, in which they could win a psychology book as a prize without any more details. At the end of the experiment they were fully debriefed on the research purposes and scope.

2.1.2. Apparatus

All sessions were conducted in a 3×2 m well lit room. Inside the room there were four desks and mounted on each of them was a computer. Three of these computers were used during the experiment. All three computers used Windows 7 Operating System. Software designed in Visual BASIC Studio 2010 was used to present the stimuli and record responses. Each participant used a set of Noise Cancelling Headphones (Panasonic Light style, Model No. RP-HX35E-K). None of the participants could see the screen of the others.

2.1.3. Procedure

Only one experimental session was carried out daily, and, for each session, three participants were ushered simultaneously to the experimental room, where they were asked to sit on a chair adjacent to each one of the computers used. During the first session, they were asked to read and sign the informed consent. At the beginning of every session, the screen displayed a series of textboxes requiring participants to fill them with their username (an alias used to identify them), the date, session number, and "password" (a code used to record their data). Once these textboxes were