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Seasonal Territoriality in the Carolina Wren, *Thryothorus ludovicianus*, to Visual and Vocal Stimuli

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A thesis  
presented to  
the faculty of the Department of Biological Sciences  
East Tennessee State University

In partial fulfillment  
of the requirements for the  
Master of Science in Biology

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by  
Mark A. Dunaway  
August, 2006

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Fred. J. Alsop, III, Chair  
Thomas F. Laughlin  
John H. Kalbfleisch

Keywords: Carolina Wren, Playback, Vocalization, Territorial, Decoy

## ABSTRACT

Seasonal Territoriality in the Carolina Wren, *Thryothorus ludovicianus*, to Visual and Vocal Stimuli

by

Mark A. Dunaway

Carolina Wrens, *Thryothorus ludovicianus*, are permanent residents throughout their range. They form pair bonds at a young age, maintain these bonds for multiple years, and defend feeding/breeding territories year round. Male Carolina Wrens use songs in territorial defense and have been shown to countersing regularly to both neighbors and intruders. They use various song characteristics to determine the location of another bird and whether its territory has been invaded.

Wrens often approach playbacks silently in apparent searching behavior. In some cases, birds will investigate the playback but fail to countersing. I wanted to determine whether or not wrens would respond more strongly during playbacks with a decoy. In addition, the experiment was conducted during breeding and nonbreeding periods to compare responses across seasons. The findings show that wrens respond more aggressively to playbacks with a decoy and to playbacks conducted during the breeding season.

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## ACKNOWLEDGEMENTS

I would like to thank Dr. Fred J. Alsop for technical assistance with decoy preparation and manuscript assistance.

I would like to thank Dr. Thomas F. Laughlin for his design suggestions and manuscript assistance.

I would like to thank Dr. John H. Kalbfleisch for funds used to purchase necessary equipment and for his assistance with statistical design and analysis.

I would like to thank the East Tennessee State University Department of Biological Sciences for the Howard Hughes Medical Institute undergraduate research grant which helped purchase necessary equipment.

I would like to thank Chris Spencer who acted as an invaluable research assistant during the project.

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## CHAPTER 1

### INTRODUCTION

The Carolina Wren, *Thryothorus ludovicianus*, (Figure 1) is in the order Passeriformes, which contains the songbirds. Carolina Wrens do not exhibit sexual dimorphism. They are considered permanent residents in Tennessee and are monogamous in that their pair bonds are maintained year round (Morton 1982, Simpson 1985). Carolina Wrens often have 2 or more broods per season, depending on latitude (Alsop 2001). Nesting usually begins in April in the Northeast Tennessee region and continues through the summer months. I have personally witnessed a pair of wrens still nesting at the beginning of August, which would not be considered a common occurrence at this time of year.



Figure 1 Carolina Wren, *Thryothorus ludovicianus*



Bird vocalizations can be broken into 2 broad categories: songs and calls. Songs are almost exclusively given by territorial male birds (Gill 1995) and are used for territory defense and attraction of mates. Songs are typically more complex and aesthetically pleasing to the ear and are often restricted to the breeding period. Calls are typically shorter and simpler in their structure and are often given by both sexes. There are many specific types of calls such as distress calls, nest calls, warning calls, etc. (Gill 1995) that can be given during both non-breeding and breeding periods.

In many songbirds, the approach of spring signals birds to begin the breeding cycle that is facilitated by the increase in hormone levels and gonad growth (Gill 1995). Many songbirds, both migratory and non-migratory, only seek out and defend territories during the breeding season. Along with this territorial defense, they also increase vocal displays in order to attract mates and establish pair bonds during this period. In some cases the period in which a male sings can be restricted even more to the first few weeks of the breeding season as is the case with some warblers where once a pair bond has been established, male songs often cease. After the breeding season, both territories and pair bonds often break down. The period following this is often characterized by a lack of territoriality and a reduction and/or elimination of male song.

Carolina Wrens are somewhat unique in that males sing year-round, which makes them ideal subjects for playback experiments. The typical male wren repertoire can range from 22 to 41 song types (Richards 1981, Morton 1982, Simpson 1985) which can vary regionally in their structure. In contrast to most North American species, Carolina Wrens maintain both territories and pair bonds year-round. Wrens respond readily to playbacks simulating intrusion and will countersing regularly to their neighboring wrens (Hyman 2003). Wrens have shown the ability to determine the approximate location of an intruder by various cues within the song. For

example, wrens have been found to use the amplitude of a song to determine other birds' locations (Richards 1981, Naguib 1997a, Naguib 1997b). Song degradation has also been shown to aid wrens in determining the location of another singing bird. When songs pass through the atmosphere, the signal can become degraded and distorted as it passes through dense vegetation like that found in wren habitats. Naguib (1997b) found that wrens can use the amount of song degradation in determining the location of other singing wrens (i.e. whether or not the source is coming from within their own territory or from a neighboring territory). Because wrens use various characteristics of a song to determine the location of its source, they are quite remarkable in their ability to quickly and accurately locate and position themselves for territorial defense. Using this locational information gathered from songs, wrens have been shown to respond more aggressively to stranger intrusions as compared to that of neighboring birds (Simpson 1985).

Various species of songbirds will often respond to playbacks by attempting to triangulate the source by flying to different points immediately surrounding it (Alsop 2006, professor of Biological Sciences East Tennessee State University, personal comments, unreferenced). During this triangulation flight they will regularly countersing in response to the playback rather than remaining quiet. Wrens, on the other hand, will often remain stationary and countersing in response to their neighbors but will aggressively approach and defend an intrusion within their territory. How aggressively a wren responds to another conspecific is not only dictated by that individual's location but whether or not this individual begins vocalizing during a territorial wren's song bout. Hymen (2003) found that wrens responded more aggressively to playbacks that were initiated during a wren's song bout versus playbacks that were initiated during a period when the territorial bird was silent. As a playback is initiated and a wren perceives this playback

as an intruder, he will approach the playback source silently as if in a stealth mode (Richards 1981; Dunaway 2002). This behavior suggests that the wren is, in fact, responding to the playback but its silent approach suggests that it is trying to locate the intruder before engaging in defensive postures and countersinging.

Previous research on Carolina Wrens using playbacks, found that territorial males did not always respond vocally to the playback by countersinging after approaching the playback source (Naguib 1997b; Dunaway 2002). Why wrens approach a simulated intrusion through playbacks but then fail to countersing suggests that these territorial birds are not just relying on auditory cues to determine a perceived threat. It appears that once an auditory signal has been detected, and perceived as an intrusion, they sometimes need a visual confirmation that an intruder is in their territory before countersinging will begin. If this is the case, wrens should respond more aggressively (i.e. countersing more frequently) when a playback is presented in combination with a decoy than to a playback by itself. In order to test this hypothesis, a decoy was made from a frozen Carolina Wren specimen that had not yet been prepared for placement in the avian study collection at East Tennessee State University (ETSU). Rather than use a static skin mount, the specimen was attached to micro servos that allowed movement by the decoy. These movements resulted in the decoy being more realistic and more closely resembling a live wren.

In the current study, playback experiments were conducted within wren territories with and without the use of the decoy. In addition to testing whether or not wrens would respond more aggressively when a visual stimulus was present, I also wanted to test whether or not wrens would defend their territories differently during breeding versus nonbreeding periods. Strain & Mumme (1988) found that there was a positive correlation between the amount of wren vocalizations and temperature. Carolina Wrens were found to vocalize more frequently in the

winter on warmer days versus days with lower temperatures. In addition to temperature having an effect on wrens' vocalizations, one would expect falling hormone levels after the breeding season to directly affect how aggressively wrens defend their territories. Wrens use and maintain a territory year round thereby allowing data from 2 periods to be compared in order to determine whether their territorial defense remains constant throughout the season. The first study period took place in the spring during breeding season and the second period was conducted in late fall/early winter during the nonbreeding period.

## CHAPTER 2

### MATERIALS AND METHODS

Beginning 10 February 2005, potential locations in upper east Tennessee were visited and examined for both accessibility and potential numbers of wren territories. Two locations in the Tri-Cities area were identified in late February as sufficient in numbers of needed territories as well as appropriate habitat requirements. Once study locations were determined, approximately three visits per week through mid-April were conducted in order to locate, map, and confirm the presence of wren territories at each location. During the initial visits at each location, potential wren territories were observed by wren vocalizations and subsequently marked using landscape marking paint and plastic marking ribbon applied to bases of trees and/or vegetation along trails. Once a potential territory was marked, each territory was re-visited multiple times from February through mid-April prior to the initiation of data collection. This observation period was continued until wrens were actively beginning to prepare and maintain nests, which was determined by observation of wrens carrying nesting material. Once confirmation of nesting was established, the spring portion of the study commenced.

The second period of the study took place in the fall during the non-breeding season. The 2 locations were the same territories that were used in the spring. After the initial study was completed in May, the locations were re-visited starting in early September during which time wrens were observed and territories located in previously-identified locations. Wrens were found in all the previously identified territories from the spring portion of the study; however, because banding was not possible due to financial and time constraints, these wrens could not be positively identified as the identical wrens that were found in these territories in the spring.

Based on the fact that wrens will use territories for multiple years (Morton 1982), and it was a relatively short period of time between the 2 study periods, it seems likely that many, if not all, were the same birds. Sixteen territories were marked for the study at both locations. Five additional territories were identified as back-up territories in the event that a territory was lost during the study.

### Study Sites

#### Winged-Deer Park

Winged-Deer Park is a city-managed park that is located in Johnson City, Washington County, Tennessee. Ten primary territories, along with 3 alternate territories were marked at the Winged-Deer site. The area in which these territories were located is the Frisbee-golf course area of the park. The habitat in the areas in which the wren territories were located consisted of mixed hardwoods, edges created by paths, small fields, roads, and dense vegetative undergrowth from blackberry vines *Rubus allegheniensis*, Japanese honeysuckle, *Lonicera japonica*, and multiflora rose, *Rosa multiflora*.

#### East Tennessee State University at Kingsport Woodlot

Six primary territories and 2 alternate territories were located on the property at East Tennessee State University at Kingsport, Hawkins County, Tennessee. The property can be characterized as consisting of 2 portions. The first is the area directly behind the main university building which is heavily wooded with a mixture of hardwoods and pines with fitness trails cutting through it. The second portion of the property, where the study wrens were located, was characterized by sporadic hardwoods and pines with a heavy growth of understory vegetation



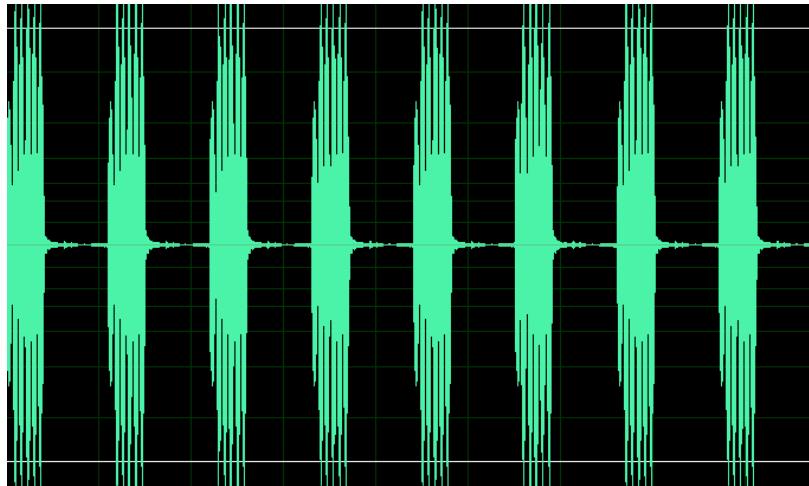
(i.e. blackberry vines, multiflora rose, and honeysuckle) with vehicle-width paths winding and looping throughout the property. Access to this portion of the property was gained through a gated entrance on Lewis Lane.

### Song Preparation

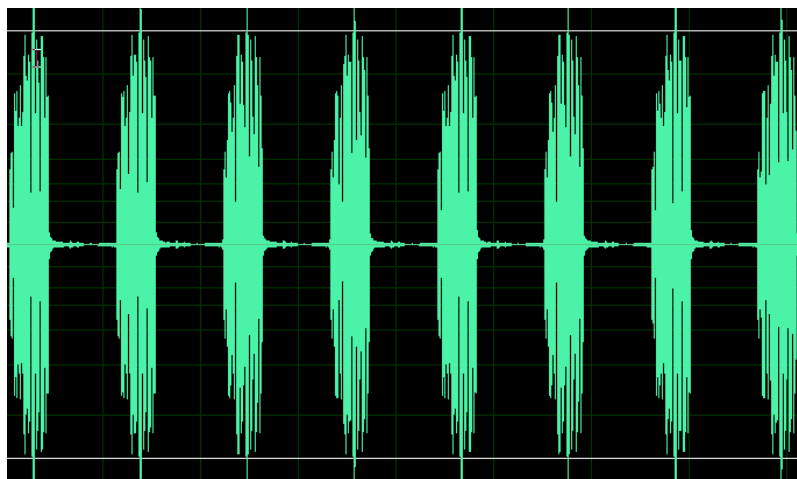
Songs can be broken down into units. A particular song type represents a unique vocalization; the total number of song types given by an individual makes up its repertoire. A particular song type may be repeated in succession, making up a unit known as a strophe. The total number of strophes given during a vocal event makes up the bout (Sossinka and Bohner 1980). Two wren song types were captured in the Cades Cove area, Blount County, Tennessee, of the Great Smoky Mountains National Park. The park is located on the Tennessee-North Carolina border in the Pigeon Forge/Gatlinburg area and encompasses over 800 square miles (Alsop 1991). Because of differences associated with regional dialect in birds, and birds' ability to personalize a particular song type, the two songs were recorded within the same region as the study sites but a sufficient distance away to guard against any unique individual characteristics that might exist in neighboring wrens in the study area. Kroodsma (1982) reported that Carolina Wrens in Ohio possess a different regional dialect by singing faster than wrens found in Florida (as cited in Gill 1995). Naguib (1997b) found that playbacks using familiar songs, which were recorded from neighboring wrens, when compared to playbacks using stranger songs (i.e. those songs recorded from non-neighboring wrens, but wrens within the same region) elicited similar responses. The 2 songs used in the current study were recorded outside of the immediate study area because Hyman (2003) demonstrated that wrens respond more aggressively to simulated stranger intrusions than to simulated neighbor intrusions.

Songs were digitally recorded using a Sennheiser MKH-70 shotgun microphone with Rycote shockmount and blimp windscreen. The recorder was a Marantz PMD-680 set at the highest quality setting: 16-bit at 768kbps. Songs were recorded at similar distances with minimal vegetation between the bird and microphone to ensure song clarity and minimize song degradation.

The 2 song types were loaded onto a Toshiba laptop running Windows Media Center edition operating system and edited with Cool Edit Pro 2.0 audio software. Each song type was copied and looped for a total of 8 strophes to make up the 2 playback bouts. Between each strophe the same 3-second section was added to ensure that both song types were identical in terms of the interval between strophes. The total bout length for each song type was 41 seconds. The variation in bout length in wrens can vary from 5 to 15 songs per minute (Haggerty and Morton 1995). The decision to use 8 strophes in a bout was simply to allow the wren a sufficient amount of time to hear the playback, approach, and locate the source, while at the same time minimizing the amount of time a territorial bird was exposed to the playback. The playback songs were not compressed or altered in any way to ensure the highest quality and eliminate accidental song degradation.



Sonogram of Song 1 bout



Sonogram of Song 2 bout

Figure 3 Song sonograms

Two different song types were used in the playback experiments in order to control and test for the possibility of song-type effect (Kroodsma 1989). Two song types made it possible to minimize the number of trials that each bird received during the study thereby reducing the possibility of habituation (Kroodsma 1989). Song type 1 can best be represented by the 2 syllable mnemonic “chiva, chiva, chiva” while song type 2 is a 3 syllable “tea kettle, tea kettle, tea kettle”.

### Robotic Wren Decoy Preparation

The Carolina Wren specimen that was used for the decoy mount was obtained from East Tennessee State University. The dead specimen had been collected by Dr. Fred Alsop and was being kept in a freezer waiting to be preserved and placed in the study collection. Prior to the preparation of the bird itself, a mounting bracket was designed and constructed. This bracket was designed in order to allow the tail of the bird to move independently without placing any stress on the skinned body portion of the bird. The bracket was constructed in 3 parts: (1) a small rectangular aluminum plate which was placed in the body cavity, (2) a hinged toggle bolt portion of a ceiling plant hook was used as the spring mechanism to which the tail attached, and (3) a heavy gauge wire, which was threaded on one end, was angled and bent to act as a mounting post for the completed bracket. The body mount post and hinged tail mechanism were then glued to the rectangular aluminum plate using epoxy (Figure 4).



Figure 4 Decoy body mount

The wren was skinned in typical taxidermy fashion. The skin was coated with Borax to aid in the preservation and drying process. Styrofoam and cotton were used as replacement body tissue. Artificial eyes were made using round headed straight pins that were painted and covered

with a clear coat of epoxy. Thin wire was used in the head and neck areas to help position the bird. The tail was removed from the skin in order to be mounted separately. The rectangular plate of the body mount bracket was inserted through the rear of the bird into the body cavity and glued into place. The separated tail section was then positioned and glued to the tail mount portion of the bracket (figure 5).



Figure 5 Wren decoy

In order to provide movement to the wren decoy, 2 Hitec brand micro servos were used to provide up and down tail movement and left and right directional control of the bird. These micro servos were chosen because of their small size and low noise output. Once the wren was fastened to the bracket, the threaded portion of the body mount post was then attached to an additional metal plate. This metal plate was glued to one of the micro servos. This servo was used to provide the up and down tail movement of the bird. This motion was achieved by attaching a small loop of monofilament fishing line to the base of the tail bracket and to the servo horn. As the servo horn rotated downward, the line pulled down on the hinge (which held the tail). When the servo was allowed to return to its original position, the spring mechanism in the

hinge raised the tail back to its original position. The bird's feet and final body position were then secured using glue and the bird was wrapped in cotton and allowed to dry for several weeks.

The second micro servo, which would control the wren's directional (left-right) movement, was glued to a thin piece of sheet metal. This servo had a large, flat servo horn that was covered with Velcro. The bottom of the tail movement servo, which was attached to the bird, was covered with the matching piece of Velcro. This allowed for attachment and detachment of the decoy when not in use. In addition to the directional micro servo, a 4-cell AA battery 6-volt receiver pack was also glued to the piece of sheet metal. This provided power to both servos. Both servos and battery pack were then connected to a 3-channel Hitec FM receiver that was also attached to the piece of sheet metal. The sheet metal was then mounted to the back of a Mineroff SME-AFS amplified field speaker using Velcro (Figure 6). The actuation of the micro servos was controlled by a handheld Hitec Lynx 3-D three-channel radio. The up and down tail movement was controlled by the radio trigger. The directional control was actuated by the steering knob.



Figure 6 Wren decoy and electronics

### Playback Preparation

A Sony MZ-NE410 minidisc player was used to play the 2 song types during the experiment. This player was chosen because it would play the PCM Wav files that allowed for the original file format to remain unaltered. Each song type was placed on a separate minidisk and labeled. During each trial the appropriate disc was chosen as dictated by each individual

trial. The minidisk player was attached to the playback speaker by a 50-foot cable that allowed the playback to be controlled from a reasonable distance. Two identical playback speakers were used. One speaker had the decoy and electronics attached, while the second speaker was stand-alone for use in trials without the decoy. Both speakers were covered with a three-dimensional camouflage fabric that allowed them to blend more naturally into the vegetation. An S-shaped metal bird feeder hook was used to hang the playback speakers in bushes and trees during playbacks. The hook itself was bent to remove its symmetrical shape and covered with an artificial vine to camouflage it as well.



Figure 7 Robotic decoy and speaker in field



A Radio Shack model 33-2055 sound level meter was used to determine the volume of each song type during playback. As suggested by Naguib (1997b) the sound level meter was set at C-weighting, fast response. The sound level meter was positioned 1 meter from the playback speaker and the volume was adjusted until it reached 90 decibels. The 90 decibel threshold was decided upon in 2 ways. In previous studies on wrens, Naguib (1997a, 1997b) used 88 decibels as the playback volume level. In addition to this reference point, I made my own decibel measurements of live singing wrens in the field by first recording the decibel level and then repeating this process with the playback speaker placed at the same location utilized by the singing wren. I found the decibel levels of the singing wrens to be comparable in range to that level suggested by Naguib (1997a, 1997b). The actual decibel level in wrens can vary, and 90 decibels is well within the range of typical wrens. Morton (1982) reported wren vocalizations reaching 110 decibels.

### Experimental Procedure

The study was conducted during 2 periods. The first phase was completed during the breeding season and the second during the non-breeding period. The study period during the breeding season ran from 20 April through 5 May 2005. The second study period ran from 2 November through 18 November 2005. The study consisted of presenting visual and vocal stimuli to 16 territorial wrens through the use of vocal playback and visual stimulation using a robotic decoy.

All wrens received each song type with and without the robotic decoy. This required a total of 4 trials for each bird (see table 1). During each seasonal period, each wren received 2 trials with song type 1 (with and without decoy) and 2 trials with song type 2 (with and without

decoy). There were a total of 4 possible playback sequences that could be assigned to each bird. Rather than assigning all 4 sequences to each bird, which would consist of 16 trials, only one sequence was assigned to each bird thereby reducing the total number of trials to 4. This was done in order to limit exposure and reduce the chance of habituation to the playback and/or decoy. The 16 birds were grouped into 4 groups of 4 individuals. Each group of 4 individuals was assigned one of the 4 playback sequences thereby allowing each of the 4 sequences to be run 4 times (Figure 8).

Sequence 1	Sequence 2	Sequence 3	Sequence 4
Trial 1: Song 1 with decoy	Trial 1: Song 1 without decoy	Trial 1: Song 2 with decoy	Trial 1: Song 2 without decoy
Trial 2: Song 1 without decoy	Trial 2: Song 1 with decoy	Trial 2: Song 2 without decoy	Trial 2: Song 2 with decoy
Trial 3: Song 2 with decoy	Trial 3: Song 2 without decoy	Trial 3: Song 1 with decoy	Trial 3: Song 1 without decoy
Trial 4: Song 2 without decoy	Trial 4: Song 2 with decoy	Trial 4: Song 1 without decoy	Trial 4: Song 1 with decoy

Table 1 Playback sequences

A research assistant aided in the collection of data. Both the research assistant and I wore Cabela's 3-dimensional camouflage leafy suits in order to conceal our presence during playbacks. During each trial, I operated the vocal playback with the minidisc recorder as well as the robotic decoy as dictated by the playback sequence. The second researcher's job was to identify approaching birds and record data. During a typical wren vocalization, a Carolina Wren will tilt its head upward and lower its tail while singing and then raise its tail between bouts. These movements are accompanied by occasional intermittent movements of head and body. This motion was replicated as closely as possible using the decoy by lowering the wren's tail

during the vocalization of the playback and occasionally providing directional change of the bird between each strophe.

During the playbacks, 4 possible responses by a territorial wren were recorded. These were as follows: (1) No response (i.e. the wren was not observed approaching the playback or vocalizing), (2) Vocal response only (i.e. the wren vocalized from a significant distance but never approached the playback setup), (3) Visual response only (i.e. a territorial wren approached the playback setup in a defensive gesture but did not vocalize), and (4) Visual and Vocal response (i.e. the wren not only approached the playback setup in a defensive posture but also countersang). The latter response was considered to be the most aggressive response possible.

Each trial was divided into 2 periods. The first period consisted of the actual playback of the 41-second bout. The second portion was a 5-minute waiting period immediately following the bout. Responses were then recorded in the corresponding periods in which they occurred (i.e. during or after playback). Each trial was immediately stopped when a maximum response was achieved (i.e. a visual and vocal identification). For example, if the playback ran for 16 seconds, and a wren approached but did not sing, the time of the visual identification would be noted, but the playback was allowed to continue. If the bird did not sing after the 41-second bout, the 5-minute waiting period would begin. Once the bird vocalized, this time would be recorded and the trial ended. If a bird approached the playback 28 seconds into the bout and vocalized, the bout would immediately be stopped, the time recorded, and the trial ended. Figure 8 is a copy of one of the 16 data sheets from the spring period of the study.

Trial 1

Winged Deer Thicket Wren

Date 4-21-05 Time 9:30am

Song 1 with bird

	Yes	No	During Playback	After Playback	Time of Occurrence
Visual ID	X		X		:45
Vocalization	X			X	2:23

Trial 2

Date 4-25-05 Time 10:01am

Song 1 without bird

	Yes	No	During Playback	After Playback	Time of Occurrence
Visual ID		X			
Vocalization	X			X	3:00

Trial 3

Date 4-28-05 Time 9:35am

Song 2 with bird

	Yes	No	During Playback	After Playback	Time of Occurrence
Visual ID	X		X		:38
Vocalization	X			X	3:43

Trial 4

Date 5-1-05 Time 9:45am

Song 2 without bird

	Yes	No	During Playback	After Playback	Time of Occurrence
Visual ID	X			X	:30
Vocalization		X			

Figure 8 Data sheet

Each trial consisted of placing the playback speaker, with or without decoy, in a tree or bush located in 1 of the wren territories. I then situated myself low in the edge of vegetation approximately 40 to 50 feet away from the speaker setup before beginning the playback. The trial was allowed to play until a wren approached and then vocalized. Upon approach and vocalization, the trial was stopped and the playback setup was immediately removed. The trial was allowed to continue until a maximum response was achieved or until the end of the second 5-minute waiting period.

The 2 locations were sometimes visited during the same day when time and weather permitted. However, each bird received only 1 trial in the 4-trial sequence per day. Once a trial had been completed, the next trial would not take place for at least 48 hours, again, to reduce the possibility of habituation.

### Data Analysis

Upon completion of the second seasonal period of the study, data from the raw data sheets were entered and analyzed in MINITAB (2000). Vocal and visual responses were analyzed separately. Each was assessed for season, song type, presence or absence of decoy, and location. A univariate Chi-Square analysis was performed to analyze the effects of each variable independent of the other 3. A multivariate logistic regression was performed to analyze the combined effect of the 4 variables of interest. A univariate Chi-Square test was used to compare responses to decoy versus non-decoy trials. A probability level of 0.05 or smaller was used for statistical significance.

To test for the possible effects of habituation to the various playback trials survival analysis was used to compare response trends for trial 1 versus trial 3 and, separately, trial 2

versus trial 4. Time to response data was further subgrouped into measurements of when the decoy was present or absent. If a bird did not respond, then it was assigned a maximum (censored) value of 341 seconds. These comparisons were made for Visual/Vocal events in both the spring and fall periods. In each time to response figure the red trend is that of the second session. A habituation effect is indicated by the red trend residing above the black trend because this indicates a slower time to response pattern. Statistical significance of these comparisons is based on the log-rank statistic.

CHAPTER 3  
RESULTS

All the vocal responses were tallied and analyzed for both study periods using Chi-Square and logistic regression (Table 2). A chi-square analysis revealed that location and song type had no effect on the number of vocal responses. There was a higher percentage of vocal responding in the spring versus the fall seasons ( $p = .013$ ). The presence of a decoy significantly increased the amount of vocal responding ( $p = .0001$ ). A Logistic regression analysis also found significant effects for season ( $p = .009$ ) and decoy ( $p = .001$ ) (Figure 9). Song type and location were not statistically related to vocal response.

		Vocal Response	Univariate p-level	Multivariate p-level
Location	JC	52.5%	0.521	0.478
	K	58.3%		
Season	Spring	65.6%	0.013	0.009
	Fall	43.8%		
Song	1	48.4%	0.156	0.122
	2	60.9%		
Decoy	No	37.5%	0.001	0.001
	Yes	71.9%		

Table 2 Vocal responding

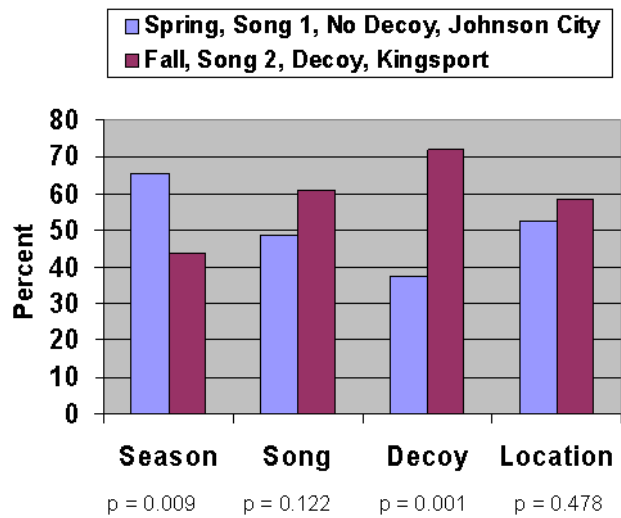


Figure 9 Vocal response

Chi-square analyses revealed that location, season, and song type had no effect on the number of visual responses (Table 3). The decoy was found to significantly increase the amount of visual responding ( $p = .0007$ ). Results from the logistic regression were in agreement with the chi-square analysis. Logistic regression revealed a significantly higher percentage of visual responses when a decoy was present (Figure 9).

		Visual Response	Univariate p-level	Multivariate p-level
Location	JC	77.5%	0.558	0.542
	K	72.9%		
Season	Spring	73.4%	0.536	0.521
	Fall	78.1%		
Song	1	70.3%	0.149	0.139
	2	81.3%		
Decoy	No	65.6%	0.007	0.008
	Yes	85.9%		

Table 3 Visual responding



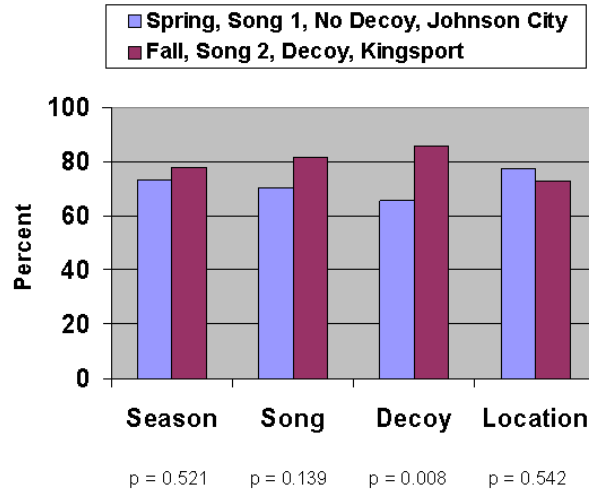


Figure 10 Visual response

A Chi-Square analysis was conducted on the effects of decoy versus no decoy on the different possible response types for the spring period (Table 4). Results revealed that the maximum response occurred when the decoy was present ( $p < .01$ ) (Figure 10).

Decoy	Neither	Vocal Only	Visual Only	Both
No	29%	13%	29%	29%
Yes	6%	3%	6%	84%

Chi-Square comparison  $p < .01$

Table 4 Spring comparison of decoy versus no decoy

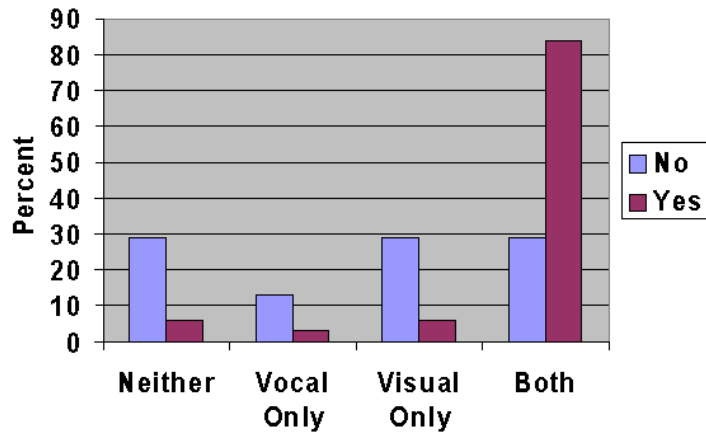


Figure 11 Spring comparison of decoy versus no decoy

A Chi-Square analysis was run on the effects of decoy versus no decoy on the different possible response types for the fall period (Table 5). Results revealed that the presence of a decoy did not have a significant effect on responding in the fall (Figure 11).

Decoy	Neither	Vocal Only	Visual Only	Both
No	19%	6%	50%	25%
Yes	16%	3%	28%	53%

Chi-Square comparison  $p = .131$

Table 5 Fall comparison of decoy versus no decoy

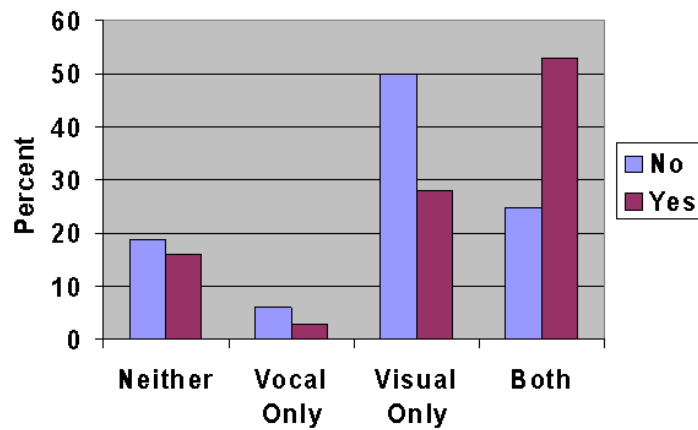


Figure 12 Fall comparison of decoy versus no decoy

Response types and timing of those responses were compared in order to determine whether birds were becoming habituated to the playbacks during the experiment. The following table of p-values (Table 6) shows only one significant comparison for the possibility of habituation. A few of the comparisons in the spring have p-levels which may suggest the possibility of habituation given a larger sample size but were not significant in the current sample. None of the comparisons in the fall were significant (Table 7).

Response Type	Decoy/No Decoy	Comparison	p-value
Visual	Decoy	1 and 3	p=.1130
Visual	Decoy	2 and 4	p=.1149
Vocal	Decoy	1 and 3	p=.0252
Vocal	Decoy	2 and 4	p=.3421
Visual	No Decoy	1 and 3	p=.1049
Visual	No Decoy	2 and 4	p=.6024
Vocal	No Decoy	1 and 3	p=.6505
Vocal	No Decoy	2 and 4	p=.8694

Table 6 Spring habituation comparisons

Figures 13 and 14 are graphical examples of the comparisons done to test for habituation. Appendices A and B contain graphs of all 16 comparisons. A trend for habituation would be represented graphically by the separation of the red and black response trends (Figure 13), where the second trend (red) is delayed relative to the first. The absence of possible habituation would be evident when the response patterns inter-mix on each other (Figure 14).

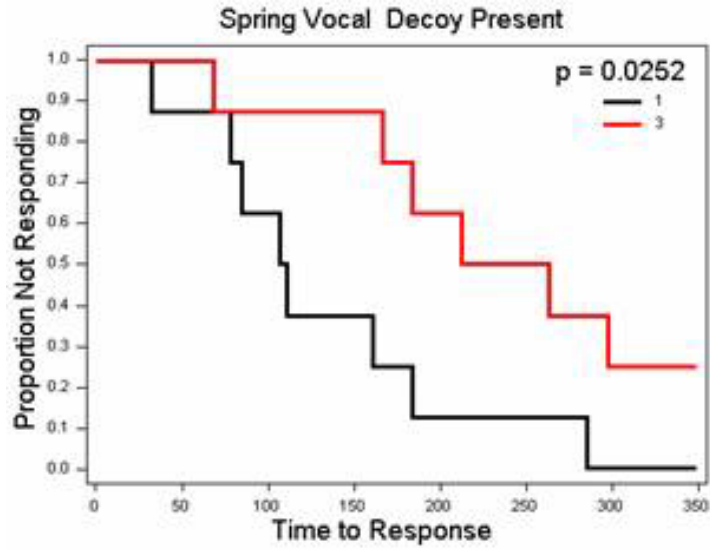


Figure 13 Spring vocal comparisons of trials 1 and 3 with decoy

Response Type	Decoy/No Decoy	Comparison	p-value
Visual	Decoy	1 and 3	p=.9822
Visual	Decoy	2 and 4	p=.9801
Vocal	Decoy	1 and 3	p=.8859
Vocal	Decoy	2 and 4	p=.2523
Visual	No Decoy	1 and 3	p=.3813
Visual	No Decoy	2 and 4	p=.8384
Vocal	No Decoy	1 and 3	p=.5973
Vocal	No Decoy	2 and 4	p=.5639

Table 7 Fall habituation comparisons

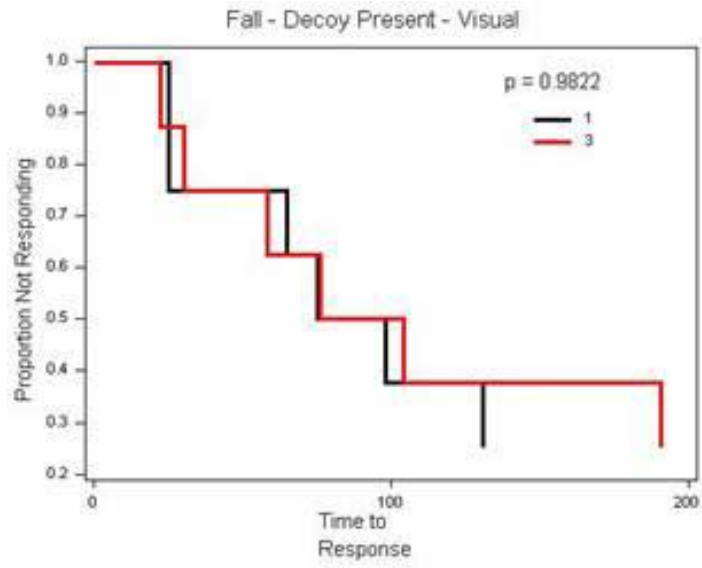


Figure 14 Fall visual comparison of trials 1 and 3 with decoy

## CHAPTER 4

### DISCUSSION

One of the problems with playback experiments is determining the cause of varying degrees of responses (i.e. strong responses versus weak responses). A strong response indicates that the receiver of the playback has recognized the playback as a threat. On the other hand, a weak response may indicate that the bird does not recognize the playback as a conspecific or it is not perceived as a threat (Weary 1992). Because Carolina Wrens often approach playbacks silently, and in some cases fail to vocalize/countersing, I hypothesized that this weaker response is because the bird is looking for a positive visual identification of the intruder before engaging or escalating to the maximum response.

Statistical analyses showed that during the spring period, playback trials using a decoy resulted in a higher number of vocal and visual responses when compared to playbacks without a decoy. When the decoy was present, a significant number of maximum responses occurred as compared to those playbacks without a decoy. This suggests that the visual stimulus provided by the decoy, in combination with the vocal stimulus, resulted in a stronger response. As an illustration, during the second playback trial using the decoy, a territorial male came in, landed on the playback speaker, and tore the tail from the decoy.

In the fall, the number of vocal responses was significantly lower when compared to the spring. Carolina Wrens clearly responded to playbacks in the fall because the number of visual responses was virtually the same as in the spring; however, the amount of countersinging was significantly lower in the fall. This suggests that that the birds are more aggressive in the spring than in the fall. Because hormone levels are at their peak during the breeding season (Gill 1995),

one would expect to observe the most aggressive behavior during this period. How aggressively wrens responded to the decoy was directly correlated to the time of year the trials took place. The frequency of the 4 response types did not change between trials with a decoy compared to trials without a decoy during the fall period. However, the frequency of response types differed significantly during the spring period, further supporting the hypothesis that wrens respond more aggressively during the breeding season.

During the data analysis, a possible trend was noticed in the time in which it took birds to respond. The possibility that habituation to the playbacks might be occurring prompted further analysis. Due to time constraints during the experiment, a visual fix on a territorial wren was not possible prior to the initiation of a playback. Because of this and the tendency of wrens to approach playbacks silently while moving through dense vegetation, an accurate measurement of time of visual identification was not possible in every case. This would explain the slightly higher number of visual responses in the fall (78.1% fall; 73.4% spring) because the foliage in the spring was much denser, which made it difficult to determine whether movement in the vegetation was a Carolina Wren or another species using that same area. This makes the comparisons of time of visual responses in the habituation tests less reliable than those comparisons using vocal responses in which the exact time of occurrence was known. In addition, because of the statistical design, the sample size in the habituation analyses was limited to 8 per comparison.

During the spring period no conclusive pattern of habituation emerged in the data analysis. Only 1 of the spring comparisons showed statistical significance for habituation. However, some comparisons showed a possible trend suggesting habituation and might have been significant in a larger sample size. Fall comparisons lacked evidence to support



habituation. The 2 comparisons that showed a slight trend toward possible habituation were not as evident as the ones found in the spring period.

When habituated, animals' responses will often tend to diminish (Weary 1992). The comparisons in the spring which showed the highest trends for habituation occurred both with and without the decoy. If we assume that habituation was indeed taking place, this would mean that the responses would decrease. Despite this possibility, the data still showed an increased response rate in those playbacks using the decoy; therefore, the presence or absence of habituation does not affect the finding that birds responded more aggressively to the presence of a decoy. If we assume habituation was occurring, a possible explanation for why trends appeared the spring and not in the fall might be that birds are simply more territorial in the spring compared to the fall. This heightened awareness results in greater ability to retain and use information from previous territorial encounters and apply this knowledge to future encounters. This suggests that birds would more readily recognize repetitive patterns like those found in the playbacks. A second explanation might be that the birds in the fall had already been habituated by the trials in the spring, and evidence of habituation was not detectable. This could explain the lower vocal responses in the fall versus the spring. However, because these two test periods were conducted several months apart, any lasting habituation effects from the spring would not be likely. In addition, the birds used in the study were not banded which made it impossible to guarantee that all the birds in the fall had been previously exposed to trials in the spring.

Because many steps were taken to reduce the possibility of habituation in the experiment, and there was not substantial evidence showing habituation, the trends that were detected were not likely due to habituation. An alternative explanation for the trends observed in the spring might instead be due to wrens' diminished ability to accurately detect and pinpoint the source of

playbacks as the trials progressed as a result of increasing density of spring vegetation. During each passing day in the spring trials, the amount of new vegetative growth increased rapidly possibly contributing to song degradation and wren's ability to detect songs during playback. In addition, both males and females may have been spending increasing amounts of time foraging during the latter periods in the spring because of offspring in the nests. This need for increased foraging time would equate to males being in more dense vegetative growth and at lower levels in the vegetation looking for invertebrates thereby limiting their ability to hear playbacks. Since neither vegetative growth nor increased foraging for offspring was not a factor during the fall period, this might explain the lack of any trends being detected during this period.

### Conclusions

The data clearly showed that territorial Carolina Wrens responded more aggressively to playbacks that used a visual decoy. This suggests that wrens use visual identification of an intruder along with song characteristics to determine the strength of their response. The data also showed that wrens vocalized, or countersang, more frequently in the spring versus the fall periods. It is unlikely that habituation could explain the reduced vocal responses in the fall since the number of visual responses did not change between the 2 periods.

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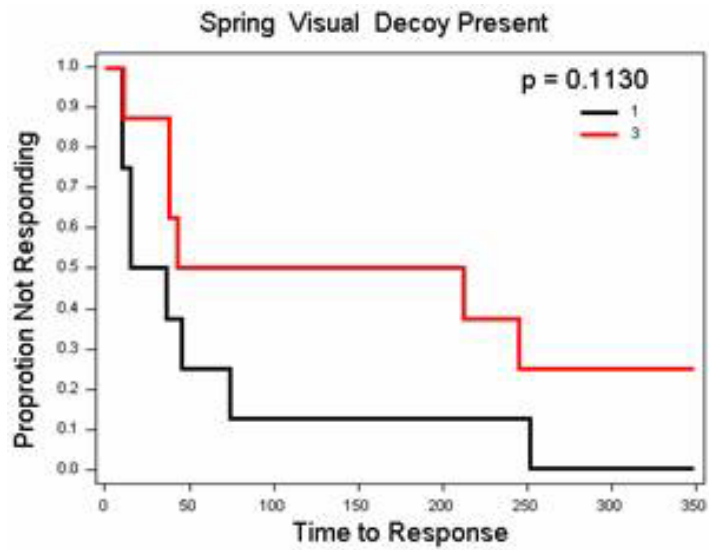
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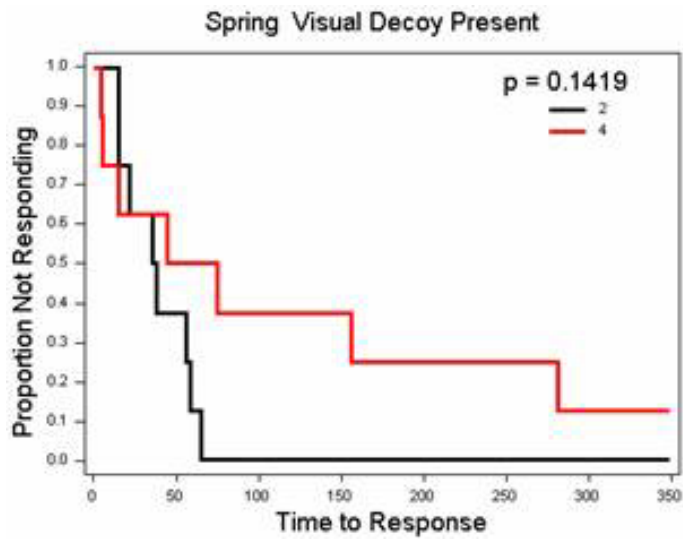
APPENDICES

APPENDIX A

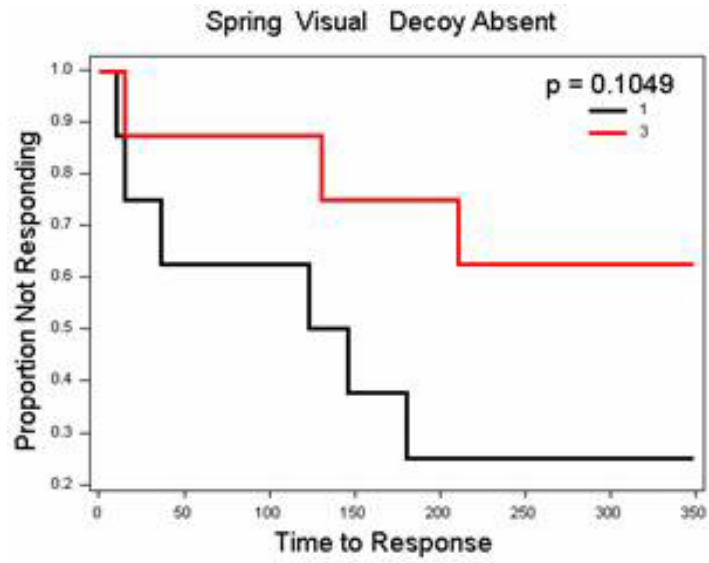
Spring Habituation Comparisons



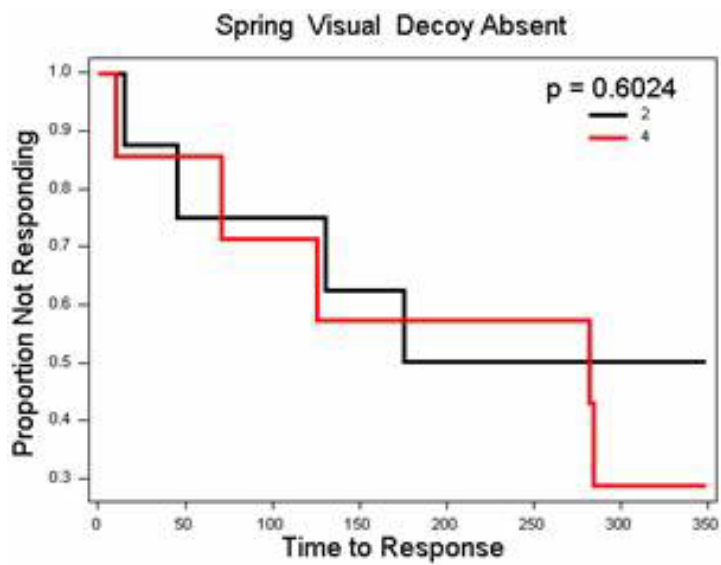
Spring visual comparisons of trials 1 and 3 with decoy



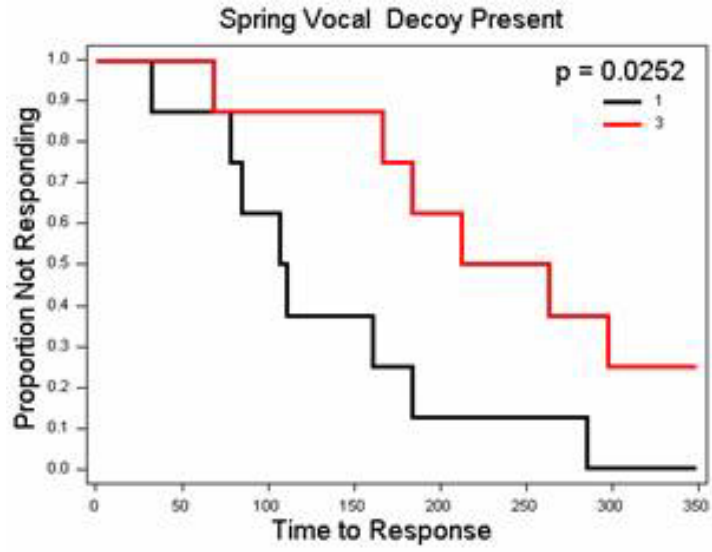
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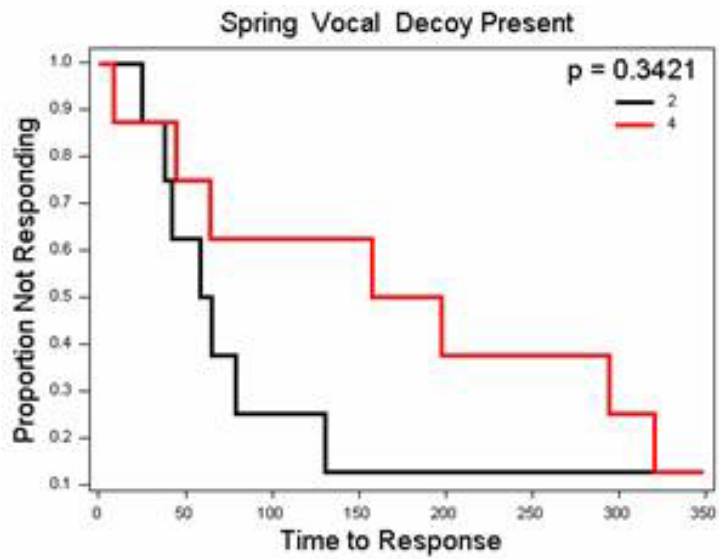
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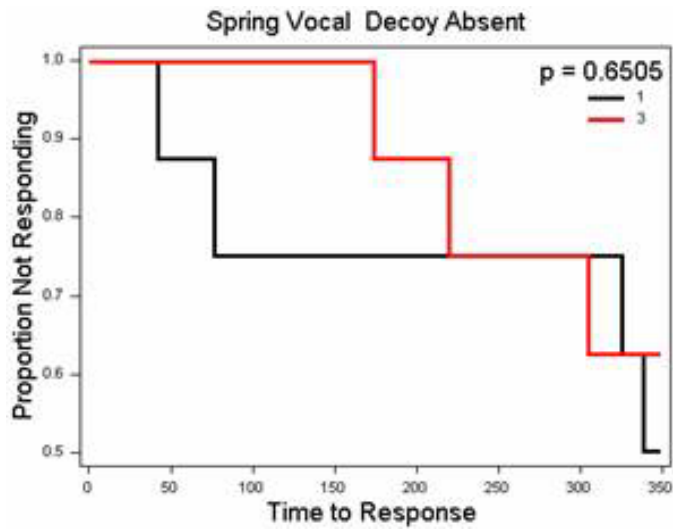
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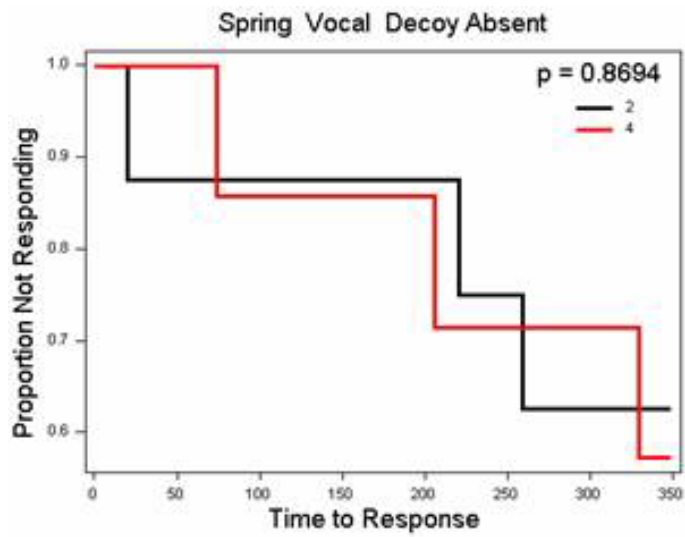
Spring vocal comparisons of trials 1 and 3 with decoy



Spring vocal comparison of trials 2 and 4 with decoy



Spring vocal comparison of trials 1 and 3 without decoy

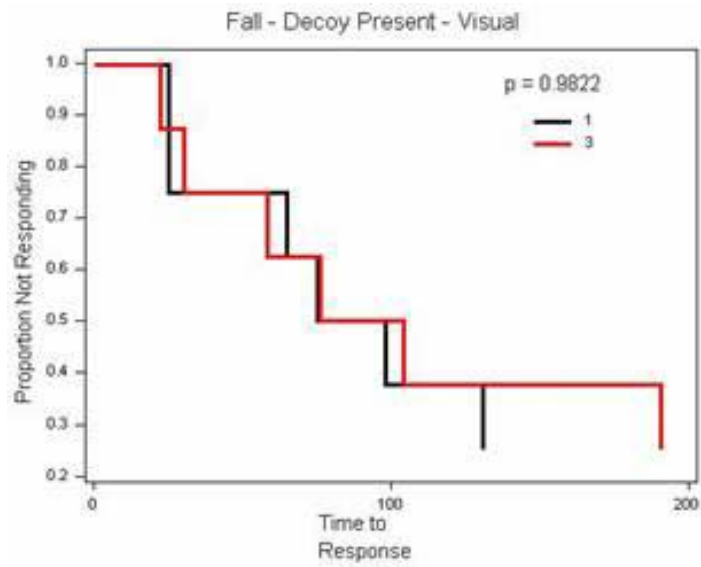


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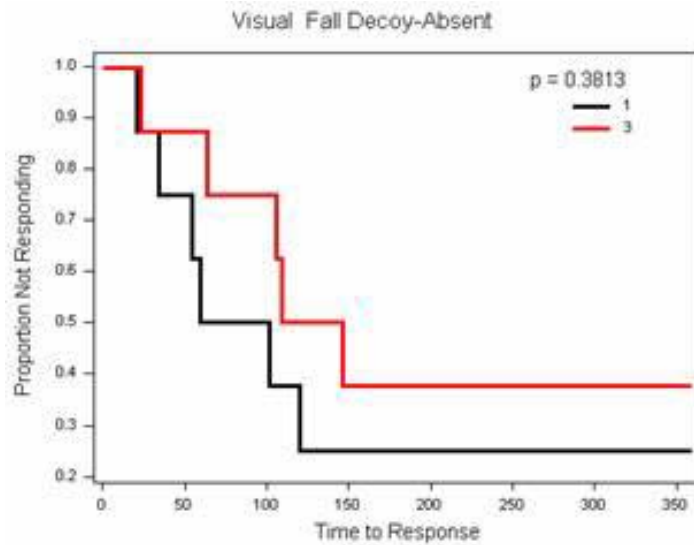


## APPENDIX B

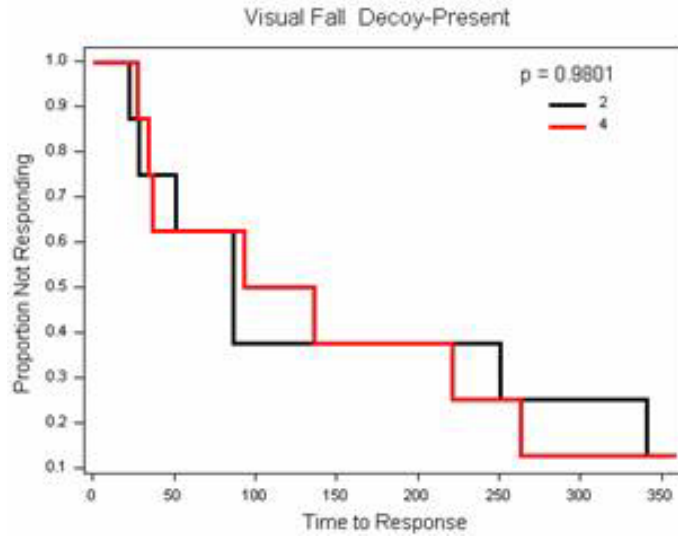
### Fall Habituation Comparisons



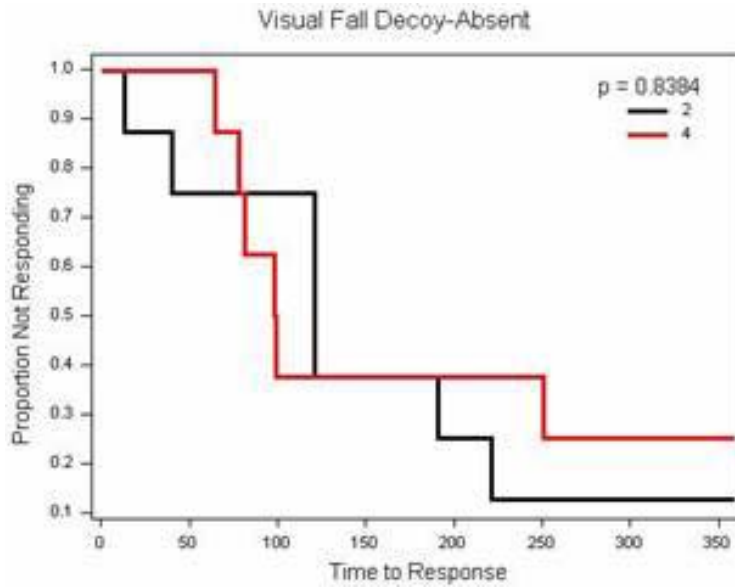
Fall visual comparison of trials 1 and 3 with decoy



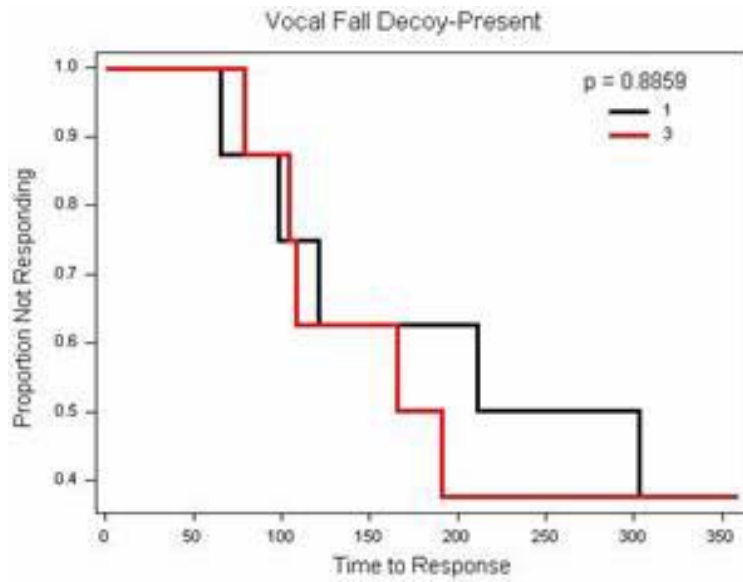
Fall visual comparison of trials 1 and 3 without decoy



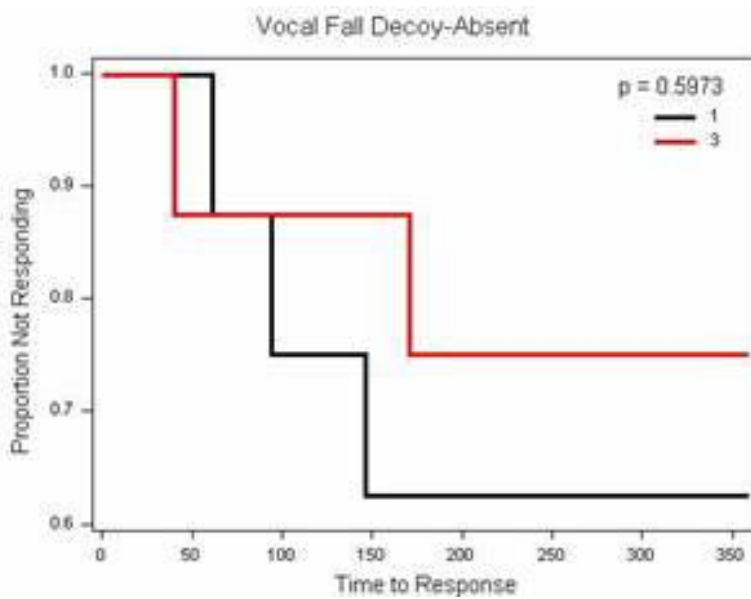
Fall visual comparison of trials 2 and 4 with decoy



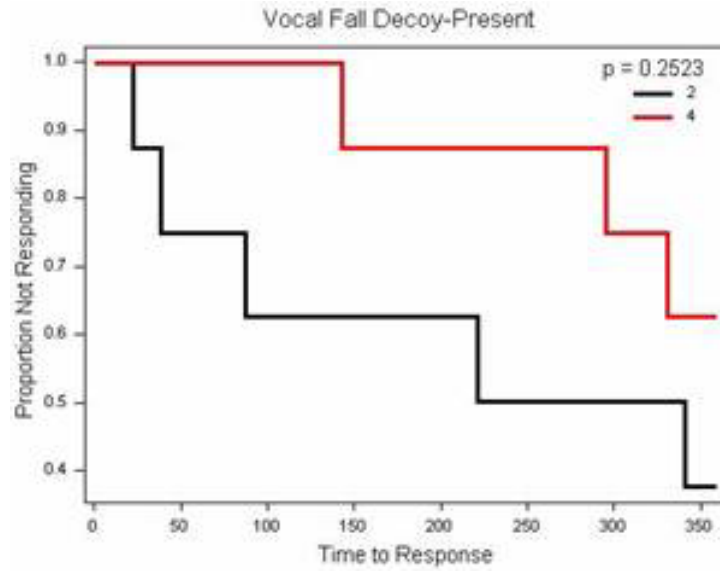
Fall visual comparison of trials 2 and 4 without decoy



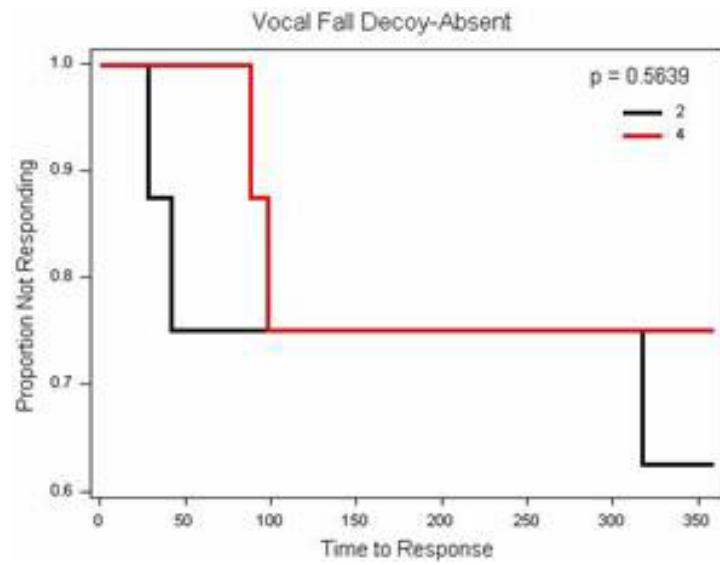
Fall vocal comparison of trials 1 and 3 with decoy



Fall vocal comparison of trials 1 and 3 without decoy



Fall vocal comparison of trials 2 and 4 with decoy



Fall vocal comparison of trials 2 and 4 without decoy

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