The Patience of Spiders: The individual differences in *Trichonephila clavipes* in response to a repeated artificial stimulus

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April 2022

Abstract:

Trichonephila clavipes, or Golden Orb-Weaver Spiders, are a species of spider that create semi-permanent webs and are highly responsive to the vibrations in their web to catch prey. It was determined that *T. clavipes* have individual responses to receiving artificial repeated stimuli. In this experiment, *T. clavipes* were given artificial stimulations separated by a predetermined amount of time in order to test whether they would repeatedly respond to vibrations in its web if there was no reward given. Through repeated tests of ten spiders over the course of four days, it was determined that spiders would respond to vibrations created by a stick. Furthermore, the data that was collected suggests that each spider had an individual number of times that they would respond to the stimulus without receiving a reward before stopping to respond.

Introduction:

Trichonephila clavipes, the Golden Orb-weaver spider, is found primarily in the Southern U.S. and the Central American tropics.[1] The females of this species are well known for building strong webs which appear a golden-yellow color. The silk of *T. clavipes*[*] has many uses, such as being used to make bags, fishing nets, and bulletproof vests[2][3]. *T. clavipes* builds its web in an orb-like shape, using special sticky silk to construct the majority of the center to catch its prey.[4] *T. clavipes* poor vision necessitates that it uses the vibrations in its web to locate prey to catch. To do this, they sit in the middle of their web with their legs connected to various strands of silk that point in every direction. This allows them to feel any vibrations on the web. When *T. clavipes* detects vibrations in its web, it faces the direction, pulls its legs closer to its abdomen to tighten the strands of silk, and moves more legs to the front of its body. When it decides to go after the vibrations, it produces some silk from its abdomen and teathers itself to the center of its web. After teathering itself, it begins to climb over its web to catch the prey. When *T. clavipes* catches new prey, it is injected with venom, then wrapped in silk and carried back to the center of the web. The wrapped-up prey hangs until the spider gets hungry, then it is slowly consumed. Because *T. clavipes* rely on the vibrations of the web, artificial stimulus in the form of vibrations

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[1] 1 Levi, H. W., and Levi, L. R. 1968. A Golden Guide: Spiders and their kin. Golden Press, New York (pg. 65)

* In this report, when referring to *Trichonephila clavipes* we are referring to the females of this species.

[2] Preston-Mafham, K, and Preston-Mafham, R. 1996. The Natural History of Spiders. The Crowood Press, UK. (pg. 44)

[3] Ceballos, L. 2022. Personal Communication.

[4] Ceballos, L

can result in the spider becoming attracted to the point of stimulus. Our focus on responses of *T. clavipes* derived from our interest in how T. *clavipes* interacts with simulations. Spiders are hard-wired invertebrates that observe the world around them, and make responses based on these observations[5]. A spider will only repair a web if it senses damage, it will only move when it senses prey or danger. We were interested in the possibility of a spider eventually learning that an observation it makes would yield no reward, and therefore the spider would not respond to the stimulus. Additionally, each response given by *T. clavipes* expended energy each time it responded to the stimulus, and continuing to respond without any reward of prey would expend a sizable amount of the spider's energy. We were wondering how the energy spent by reacting to vibrations in the web would affect how the spider responded. The aim of this study was to test the hypothesis that spiders would only respond to vibrations in the web if they were caused by insects, or if spiders instead would respond to artificial vibrations in a pattern based on any other factors, such as the time between simulations, or the time of day.

Methods and Materials:

The ten spiders that were tested were found at the ITEC field station in Bocas Del Toro on Isla Colón in many different spots. Five were close together, outside of the dining hall and kitchen, three were underneath the dorms, and one behind the laboratory. Vibrations were created with a long, narrow stick, and the same stick was used by the same person for every trial series to ensure there weren't differences in the simulations being provided to the web from spider to spider. The stick was placed between openings in the web about one foot away from the center where the spider resides. The stick was slowly shaken back and forth to mimic the patterns and magnitude of the vibrations created by an insect caught in a web. When *T. clavipes* sensed the vibrations and climbed down near the location of the stick it was pulled away. When the spider returned to its resting position, a timer was used to count ten seconds until and then the next stimulation began. If a spider failed to display initial interest in the stimulation, the intensity of the shakes was increased to ensure that the spider was adequately stimulated. If there was still no response, the location of the stimulus was changed. After one minute, if the spider had still not displayed any interest, the trial series was over, and the number of responses was recorded. Once a trial series ended with a specific spider, it was not tested again for at least six hours. All of the spiders were tested at various times which were recorded before the trial began.

Results:

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[5] Ceballos, L

Despite receiving no prey after responding to vibrations in the web, *T. clavipes* responded to vibrations(Table 1). Certain spiders responded more times than others despite receiving identical stimuli (Figure 1). Each individual spider would respond to simulations similarly in each of trial series' it was tested in. These results were highly significant (n = 10, degrees of freedom = 9, p-value = 0.001006). The time of day did not have a significant effect on the number of times that a spider responded to vibrations in the web (n = 10 degrees of freedom = 9, p-value 0.996683).

Table 1: The number of responses* of each spider during each trial series+.

Number of Responses for Each Spider	Spider 1	Spider 2	Spider 3	Spider 4	Spider 5	Spider 6	Spider 7	Spider 8	Spider 9	Spider 10
Trial Series 1	8	9	6	2	2	1	10	1	1	1
Trial Series 2	7	8	12	2	4	1	10	1	1	1
Trial Series 3	6	N/A**	9	3	N/A	N/A	4	1	N/A	2

* A response was considered as the spider exhibiting interest in the vibrations we created by moving towards the direction of the stimulus

+ A trial series was the period of time where a spider was stimulated until either the spider responded by moving towards the vibrations, or did not respond in any way for a minute. If the spider responded, it was given time to return back to the center of its web, and the process was repeated. When the spider stopped responding, the trial series was over, and the spider was not tested for at least 6 hours.

** There was no data collected during this test, or this test was not performed on this specific spider.

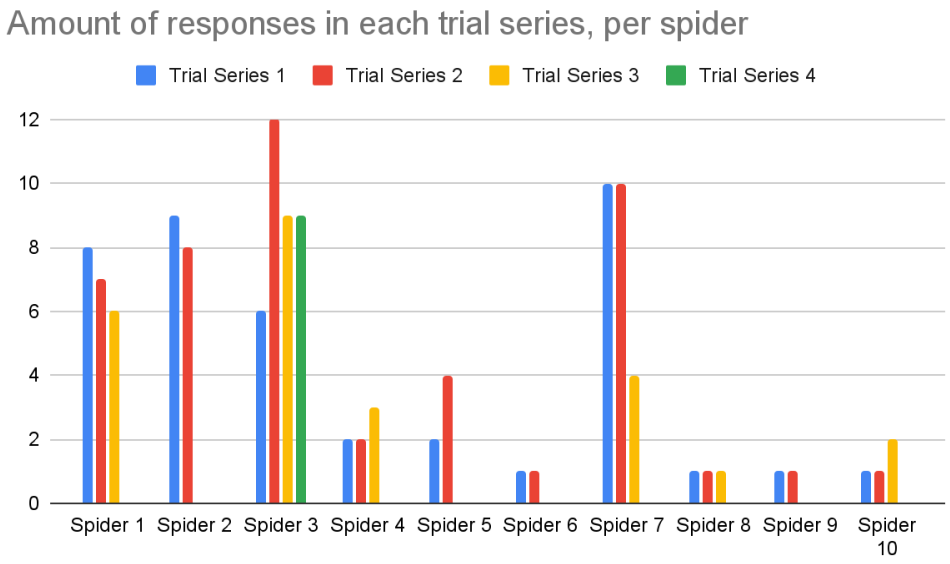

Figure 1: Figure 1 above shows the number of responses of each spider in every test that spider underwent. This shows how each spider's data is very similar from test to test.

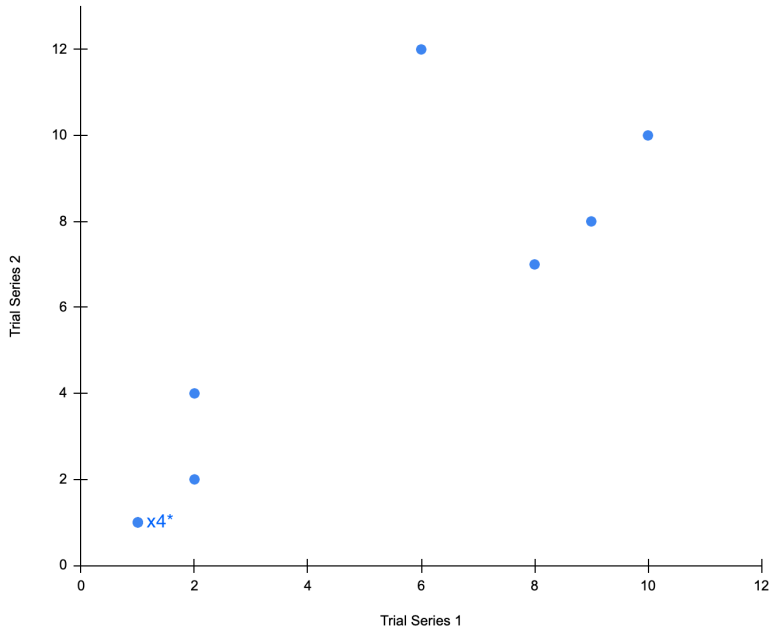

Figure 2: The results of each spider plotted with the x position of each point referring to the number of responses in the first trial series, and the y position being the number of responses in the second trial series.

* There are four points of data at this specific point (1,1)

Discussion:

After the spiders were tested with differeing intervals of time between stimulations it became apparent that there was a stronger connection between individual spiders' consistency than the difference caused by the intervals of time changing. After making this realization, new questions arose: would a spider continue to respond to repeated artificial stimuli if there was no reward? Does each individual spider have a limit to the number of times it would be willing to respond to these vibrations? Does the time of day have an impact on this? Our data suggests that each spider had a different maximum number of times it will respond.The significant correlation between trials of individual spiders indicates that each spider had a unique response to the stimuli. The spiders responded similarly regardless of the time of day and amount of light present. This suggests that external sources did not dictate how many times the spider responds to the vibrations caused by the stick. Instead, each spider had an internal indicator that determines how many times it responded to a stimulus without any success until it stopped responding. The idea that spiders possess unique characteristics that are unaffected by external factors elevates them beyond the realm of action-based observations. If spiders only acted because of stimulations from the outside world, they would always respond to stimulus, reward, or no reward. Spiders

will eventually ignore the instincts that keep them alive by indicating when prey was caught because they have the ability to quickly adapt to a response that has no reward. Additionally, this limit was different for every spider, which indicates that some factor was the cause of this limit. The locations of the webs were predetermined, so we were not in control of the surroundings or other factors such as web size, age, or light exposure. We also were unable to observe the entirety of their daily eating habits so we did not know how often or how many times they catch prey. To further prove these results, more data would have to be recorded. Although the results of our study are promising, the sample size was small. Increasing the number of trials and the number of spiders would lead to stronger data. To follow up with this study, the exploration of why a spider eventually responds would be conducted. Each spider could be monitored for the amount of energy spent on each response to the artificial stimulus based on the speed of response, the distance between the spider's location of rest and the stimulus, and the prey the spider had consumed before the trial began.

Conclusion:

It was found that *Trichonephila clavipes* consistently responds to artificial stimuli at a rate unique to each individual by creating vibrations in its web that cause it to travel to the point of stimulus. It was also found that time of day does not affect *Trichonephila clavipes* response to repeated artificial stimuli.

Works Cited:

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Appendix:

Table of the raw collected data from this expirament:

	Spider 1	**Spider 2**	**Spider 3**	**Spider 4**	**Spider 5**	**Spider 6**	**Spider 7**	**Spider 8**	**Spider 9**	**Spider 10**
Trial 1	8 (4:23 pm)	9 (8:46 pm)	6 (8:52 am)	2 (3:27 pm)	2 (11:15 am)	1 (2:19 pm)	10 (9:35 am)	1 (11:00 am)	1 (8:47 pm)	1 (2:27 pm)
Trial 2	7 (7:22 pm)	8 (3:29 pm)	12 (11:00 am)	2 (11:13 am)	4 (8:56 am)	1 (9:04 am)	10 (2:30 pm)	1 (1:52 pm)	1 (1:47 pm)	1 (7:40 pm)
Trial 3	6 (1:52 pm)		9 (2:01 pm)	3 (8:54 am)			4 (9:15 am)	1 (9:28 am)		2 (9:35 am)
Trial 4			9 (9:05 am)							

Data from the experiment without time of recording:

	Spider 1	Spider 2	Spider 3	Spider 4	Spider 5	Spider 6	Spider 7	Spider 8	Spider 9	Spider 10
Trial Series 1	8	9	6	2	2	1	10	1	1	1
Trial Series 2	7	8	12	2	4	1	10	1	1	1
Trial Series 3	6		9	3			4	1		2
Trial Series 4			9							

Number of responses to vibrations in web for each spider split into AM and PM

	Spider 1 AM	Spider 1 PM	Spider 2 AM	Spider 2 PM	Spider 3 AM	Spider 3 PM	Spider 4 AM	Spider 4 PM	Spider 5 AM	Sider 5 PM	Spider 6 AM	Spider 6 PM	Spider 7 AM	Spider 7 PM	Spider 8 AM	Spider 8 PM	Spider 9 AM	Spider 9 PM	Spider 10 AM	Spider 10 pM
Trial 1		8		9	6	9	2	2	2		1	1	10	10	1	1		1	2	1
Trial 2		7		8	12		3		4				4		1			1		1
Trial 3		6			9															

Raw data sorted into columns:

Trial	Spider	# of Responses	Time of Day
1	1	8	16:23
2	1	7	19:22
3	1	6	13:52
4	2	9	20:46
5	2	8	15:29
6	3	6	8:52
7	3	12	11:00
8	3	9	14:01
9	3	9	9:05
10	4	2	15:27
11	4	2	11:13
12	4	3	8:54

13	5	2	11:15
14	5	4	8:56
15	6	1	14:19
16	6	1	9:04
17	7	10	9:35
18	7	10	14:30
19	7	4	9:15
20	8	1	11:00
21	8	1	13:52
22	8	1	9:28
23	9	1	20:47
24	4	1	13:47
25	10	1	14:27
26	10	1	19:40
27	10	2	9:35