Pendulum period

Does a pendulum's period change as its swing gets smaller? This method times a pendulum at a large and at a small swing, compares the two periods, and revises the starting hypothesis.

This method is written in ScienceLogo: https://sciencelogo.org/

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1 Overview

Does a pendulum's period change as its swing gets smaller? This method times a pendulum at a large and at a small swing, compares the two periods, and revises the starting hypothesis.

1.1 Method

- **Prepare** (p. 4), by *assistant* (p. 3)
- **Observe** (p. 5), by *assistant* (p. 3)
  - `calculate-period` (p. 7)
- **Compare** (p. 8), by *researcher* (p. 3)
  - `compare-periods` (p. 8)
- **Revise** (p. 9)

1.2 Performers

assistant: kind: human; role: laboratory assistant. Stages: **Prepare** (p. 4), **Observe** (p. 5)

researcher: kind: human; role: scientist. Stages: **Compare** (p. 8)

1.3 Hypotheses

shorter-swing A smaller swing has a shorter period.

1.4 Assumptions

hand-timing Hand timing is comparable across trials.

1.5 Conclusions

regular-period The period stayed nearly constant as the swing got smaller.

1.6 Requirements

- Stages run in this order: **Prepare** (p. 4) → **Observe** (p. 5) → **Compare** (p. 8) → **Revise** (p. 9).

STAGE

2 Prepare

Set up a pendulum of fixed length and a hand stopwatch, and decide to time ten full swings in each trial.

Performer *assistant* (p. 3)

Starts with
information:
  swing-count: 10
environment:
  pendulum:
    length: 1 m
  timer: “hand stopwatch”
factors:
  reaction-time: unknown

Ends with
information:
  swing-count: 10
environment:
  pendulum:
    length: 1 m
  timer: “hand stopwatch”
factors:
  reaction-time: unknown

```
start stage Prepare by assistant from state [
  set information to [set swing-count to 10]
  set environment to [
    set pendulum to [set length to 1 set unit to "m"]
    set timer to "hand stopwatch"
  ]
  set factors to [set reaction-time to unknown]
]
  about "Set up a pendulum of fixed length and a hand stopwatch, and decide to
  time ten full swings in each trial."
end stage with state [
  set information to [set swing-count to 10]
  set environment to [
    set pendulum to [set length to 1 set unit to "m"]
    set timer to "hand stopwatch"
  ]
  set factors to [set reaction-time to unknown]
]
```

STAGE

3 Observe

Time ten full swings at a large and at a small swing, and derive the period of each.

Performer *assistant* (p. 3)

Starts with

information:
  large-swing:
    elapsed: 20.1 ± declared reaction-time (type epistemic, estimate 0.2 s)
    swing-count: 10
    unit: “s”
  small-swing:
    elapsed: 20 ± declared reaction-time (type epistemic, estimate 0.2 s)
    swing-count: 10
    unit: “s”
environment:
  pendulum:
    length: 1 m
  timer: “hand stopwatch”
factors:
  reaction-time: unknown

Steps

1. `calculate-period` (p. 7) by *assistant* (p. 3), with `elapsed` from `information.large-swing.elapsed`, `swings` from `information.large-swing.swing-count`, into `information.large-swing.period`
2. `calculate-period` (p. 7) by *assistant* (p. 3), with `elapsed` from `information.small-swing.elapsed`, `swings` from `information.small-swing.swing-count`, into `information.small-swing.period`

Changes

- information.large-swing.period added
- information.small-swing.period added

Ends with

information:
  large-swing:
    elapsed: 20.1 ± declared reaction-time (type epistemic, estimate 0.2 s)
    swing-count: 10
    unit: “s”
    period: unknown
  small-swing:
    elapsed: 20 ± declared reaction-time (type epistemic, estimate 0.2 s)
    swing-count: 10
    unit: “s”
    period: unknown
environment:

pendulum:

length: 1 m

timer: “hand stopwatch”

factors:

reaction-time: unknown

```
start stage Observe by assistant from state [
  set information to [
    set large-swing to [
      set elapsed to 20.1 with uncertainty [
        set declared to [set reaction-time to [set type to "epistemic" set estimate to 0.2
set unit to "s"]]
      ]
      set swing-count to 10
      set unit to "s"
    ]
    set small-swing to [
      set elapsed to 20.0 with uncertainty [
        set declared to [set reaction-time to [set type to "epistemic" set estimate to 0.2
set unit to "s"]]
      ]
      set swing-count to 10
      set unit to "s"
    ]
  ]
  set environment to [
    set pendulum to [set length to 1 set unit to "m"]
    set timer to "hand stopwatch"
  ]
  set factors to [set reaction-time to unknown]
]
  about "Time ten full swings at a large and at a small swing, and derive the
  period of each."
  do calculate-period with [
    elapsed at elapsed of information.large-swing
    swings at swing-count of information.large-swing
  ] into period of information.large-swing
  do calculate-period with [
    elapsed at elapsed of information.small-swing
    swings at swing-count of information.small-swing
  ] into period of information.small-swing
end stage with state [
  set information to [
    set large-swing to [
      set elapsed to 20.1 with uncertainty [
        set declared to [set reaction-time to [set type to "epistemic" set estimate to 0.2
set unit to "s"]]
      ]
      set swing-count to 10
      set unit to "s"
      set period to unknown
    ]
    set small-swing to [
      set elapsed to 20.0 with uncertainty [
        set declared to [set reaction-time to [set type to "epistemic" set estimate to 0.2
set unit to "s"]]
      ]
      set swing-count to 10
      set unit to "s"
      set period to unknown
```

```
    ]
  ]
  set environment to [
    set pendulum to [set length to 1 set unit to "m"]
    set timer to "hand stopwatch"
  ]
  set factors to [set reaction-time to unknown]
]
```

3.1 calculate-period

Divide the elapsed time by the number of full swings.

Inputs `elapsed`, `swings`

Called by **Observe** (p. 5)

```
to calculate-period :elapsed :swings [
  about "Divide the elapsed time by the number of full swings."
  output :elapsed / :swings
]
```

STAGE

4 Compare

Compare the two periods. A difference within the timing uncertainty does not support the starting hypothesis.

Performer *researcher* (p. 3)

Starts with information:

large-period: 2.01

small-period: 2

unit: “s”

Steps

1. `compare-periods` (p. 8) by *researcher* (p. 3), with `large` from `information.large-period`, `small` from `information.small-period`, into `information.difference`

Changes

- information.difference added

Ends with information:

large-period: 2.01

small-period: 2

unit: “s”

difference: unknown

```
start stage Compare by researcher from state [
  set information to [set large-period to 2.01 set small-period to 2.00 set unit to "s"]
]
  about "Compare the two periods. A difference within the timing uncertainty
  does not support the starting hypothesis."
  do compare-periods with [
    large at large-period of information
    small at small-period of information
  ] into difference of information
end stage with state [
  set information to [
    set large-period to 2.01
    set small-period to 2.00
    set unit to "s"
    set difference to unknown
  ]
]
```

4.1 compare-periods

Subtract the period at a small swing from the period at a large swing.

Inputs `large`, `small`

Called by **Compare** (p. 8)

```
to compare-periods :large :small [
  about "Subtract the period at a small swing from the period at a large swing."
  output :large - :small
]
```

STAGE

5 Revise

Record that the measurements did not support the starting hypothesis, and state the new one: the period is nearly constant within the observed range.

```
start stage Revise
  about "Record that the measurements did not support the starting hypothesis,
  and state the new one: the period is nearly constant within the observed
  range."
```

6 Reference

6.1 Timing

Version 1.

Field	Kind	Default	Required
`elapsed`	number		yes
`swing-count`	number		yes
`unit`		"s"	yes

```
interface Timing [
  version "1"
  must [elapsed is a number swing-count is a number set unit to "s"]
]
```

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Stages

Compare 3, **8**
Observe 3, **5**, 7
Prepare 3, **4**
Revise 3, **9**

Procedures

`calculate-period` 3, 5, **7**
`compare-periods` 3, **8**

Performers

assistant **3**, 4, 5
researcher **3**, 8

Record types

Timing **10**
- `elapsed` **10**
- `swing-count` **10**
- `unit` **10**

Requirements

Stage order **3**