KIN479 - Lab: Action Preparation and Mental Chronometry

KIN 479 - Motor Control | Based on Donders' Subtraction Method

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Table of contents

1 Overview

Welcome to the Action Preparation lab! This experiment measures how quickly you can react to different types of information processing demands (Henry & Rogers, 1960). It is based on the classic work of F.C. Donders (Donders, 1969), a Dutch physician who pioneered the use of reaction time to study mental operations.

1.1 Credits

The reaction time webapp used in this lab is a fork of a Github repository by: (2025)

! Two-Part Lab Structure

Part 1 (In-Class): Data collection using the reaction time experiment
Part 2 (At-Home): Analysis and written responses to lab questions

1.2 Learning Objectives

After completing this lab, you will be able to:

1. **Understand Mental Chronometry**: Explain how reaction time can be used as an index of action preparation and mental processing time
2. **Apply Donders' Subtraction Method**: Use the subtraction method to isolate specific cognitive processes involved in action preparation
3. **Analyze RT Components**: Distinguish between simple reaction, choice reaction, and discrimination reaction time tasks
4. **Interpret RT Data**: Explain how different task characteristics influence preparation time and overall performance
5. **Connect Theory to Practice**: Relate experimental findings to real-world motor control situations

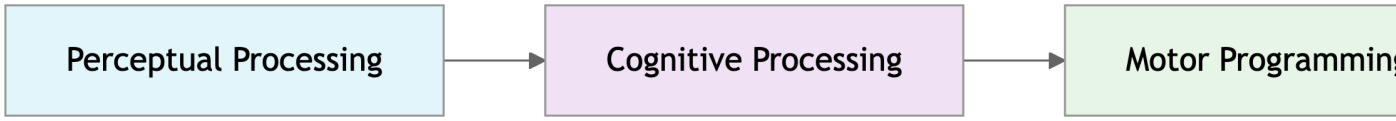
1.3 Background Theory

1.3.a Mental Chronometry and Action Preparation

The principle that the motor control system requires preparation before it can initiate an action has its roots in research conducted in the mid-nineteenth century by Donders (Magill & Anderson, 2017). This principle is derived from an inference based on the effects of various factors on differences in the amount of time between the onset of a signal telling a person to begin performing a skill and the instant researchers actually observe the beginning of movement.

Reaction Time (RT) serves as an index of the preparation required to produce an action. When considered in the context of action preparation, RT reflects the time needed for:

1. **Perceptual Processing**: Detecting and identifying the stimulus
2. **Cognitive Processing**: Making decisions about the appropriate response
3. **Motor Programming**: Preparing the motor system for action



1.3.b Donders' Three Methods

Donders hypothesized that specific mental operations occur in a specific series of stages during the RT interval. He developed three different methods for performing reaction-time tasks:

Theory	Real-World Example
Simple Reaction Time (Method A): Press a key as soon as a light appears • Involves: Stimulus detection + Motor response • Baseline measurement of sensorimotor processing	**Method A (Simple RT)**: "Catch the ball when I toss it to you" • **Stimulus**: Ball appears/is tossed • **Response**: Catch the ball (single, predetermined response) • **Involves**: Stimulus detection + Motor response
Choice Reaction Time (Method B): Press different keys for different stimuli • Involves: Stimulus detection + Stimulus identification + Response selection + Motor response • Adds response selection to the baseline	**Method B (Choice RT)**: "If I toss a red ball, catch it with your right hand; if I toss a blue ball, catch it with your left hand" • **Stimulus**: Red ball OR blue ball • **Response**: Right hand catch OR left hand catch • **Involves**: Stimulus detection + Stimulus identification (color) + Response selection (which hand) + Motor response
Discrimination Reaction Time (Method C): Respond to target stimuli only • Involves: Stimulus detection + Stimulus discrimination + Motor response • Adds stimulus discrimination to simple RT	**Method C (Discrimination RT)**: "Only catch the ball if it's red; ignore blue balls" • **Stimulus**: Red ball OR blue ball (but only respond to red) • **Response**: Catch red ball (no response to blue) • **Involves**: Stimulus detection + Stimulus discrimination (is it red?) + Motor response

! The key differences:

- **Simple RT**: Just react to any ball toss
- **Choice RT**: Different responses based on ball characteristics
- **Discrimination RT**: Only respond to specific target stimuli (red balls)

1.3.c The Subtraction Method

Donders developed the subtraction method to determine the speed of specific mental operations:

- **Stimulus Discrimination Time** = Discrimination RT - Simple RT
- **Response Selection Time** = Discrimination RT - Choice RT

2 Lab Practice

2.1 Interactive Demonstration: Understanding Donders' Subtraction Method

Before conducting the actual experiment, practice with this interactive demonstration to understand how the subtraction method reveals different cognitive processes.

How This Demo Works

1. **Generate Mock Data**: Click to create realistic reaction time data based on research findings
2. **Visualize Results**: See how RT increases with task complexity
3. **Understand Calculations**: Learn how subtraction isolates specific mental processes

3 Pre-Lab Preparation

3.1 Required Reading

Before starting the lab, review:

- **Textbook Chapter 8**: "Action Preparation" (pages 173-187)
- Focus on sections covering:
  - Task and situation characteristics influencing preparation
  - Hick's law and number of response choices
  - Stimulus-response compatibility
  - Movement complexity effects

3.2 Key Concepts to Review

1. **Hick's Law**: RT increases logarithmically as the number of stimulus-response choices increases
2. **Stimulus-Response Compatibility**: The relationship between stimulus characteristics and required responses affects RT

3. **Action Preparation Components**: Premotor and motor components of reaction time
4. **Choice vs. Simple RT**: Understanding why choice situations take longer to process

4 Part 1: In-Class Data Collection

> **What You'll Do in Class**
>
> 1. Complete the three-task reaction time experiment
> 2. Record your results from each task
> 3. Download your raw data file
> 4. Take notes on your observations

4.1 Equipment Needed

- Computer with internet browser
- Quiet classroom environment
- Notepad for recording observations and results

4.2 Experimental Tasks

You will complete three tasks in sequence, each with 10 trials:

4.2.a Task A: Simple Reaction Time

- **Stimulus**: Green circle appears on screen
- **Response**: Press SPACEBAR as quickly as possible
- **Purpose**: Establish baseline sensorimotor processing time

4.2.b Task B: Categorization (Choice Reaction)

- **Stimulus**: Random number (1-9) appears
- **Response**: Press 'J' for EVEN numbers, 'K' for ODD numbers
- **Purpose**: Add response selection demands

4.2.c Task C: Mental Arithmetic (Categorization + Choice)

- **Stimulus**: Simple addition equation (e.g., "2 + 4 = 6")
- **Response**: Press 'J' if equation is TRUE, 'K' if FALSE
- **Purpose**: Add cognitive evaluation demands

4.3 Data Collection Steps

Important: The experiment will ask for your name at the beginning to ensure your results are properly identified.

> **Privacy Notice**
>
> Your name is stored **locally on your device only** during the experiment session. It is not transmitted online or saved to any external servers. The name is only used to label your results and downloads for easy identification.

1. **Access the Experiment**: Open the lab in your browser
2. **Enter Your Name**: The experiment will prompt you to enter your full name first
3. **Read Instructions**: Carefully read all on-screen instructions for each task
4. **Complete Each Task**: Follow the prompts for all three tasks (A, B, C)
5. **Download Results**: Choose from two download options:
   - **CSV Data**: Use "Download Raw Data (CSV)" for detailed trial-by-trial data
   - **PDF Summary**: Use "📄 Download Results (PDF)" for a complete formatted report
6. **Save Files**: Both downloads will include your name for easy identification

5 Data Analysis

5.1 Calculating Mental Process Times

Using your results, calculate:

1. **Categorization Time**: Task B RT - Task A RT
2. **Mental Arithmetic Time**: Task C RT - Task B RT

5.2 Expected Results

Typical findings show:

- **Simple RT (Task A)**: ~200-300 ms
- **Choice RT (Task B)**: ~400-600 ms
- **Complex Choice RT (Task C)**: ~600-900 ms

Individual results may vary based on:

- Age and experience
- Alertness level
- Practice effects
- Stimulus-response compatibility

5.3 Data Interpretation

Consider these factors when analyzing your results:

1. **Task Complexity**: How did RT change as cognitive demands increased?
2. **Accuracy vs. Speed**: Were there speed-accuracy trade-offs?
3. **Individual Differences**: How do your results compare to class averages?
4. **Real-World Applications**: Where might these findings apply in motor skills?

6 Part 2: At-Home Analysis and Questions

6.1 Canvas Submission Requirements

i What to Submit

Submit the following to Canvas:

1. **Completed Lab Questions**: Answer all 5 questions thoroughly
2. **Your Experiment Data**: Upload the PDF summary report (includes table and chart)
    1. If the rendered PDF does not contain the chart, take a screenshot of both the results table and the chart, save the image and convert it to PDF before submitting it.
3. **File Identification**: All downloads automatically include your name for easy identification

! Submission Format

- **Question Answers**: Type your responses directly into the Canvas text box - **DO NOT upload a separate file for answers**
- **Data Files**: See above
- **File Naming**: The experiment automatically names files with your name (e.g., "John_Smith_RT_Results.pdf")
- **Data Integrity**: Use only the data generated by the actual experiment - manual data entry is not permitted

Submission Checklist:

- ☐ All 5 questions answered in Canvas text box
- ☐ PDF summary report uploaded
- ☐ Files contain your name for easy identification
- ☐ Data is authentic from the actual experiment (no manual entry)

6.2 Data Analysis Requirements

Before answering the questions, make sure you have:

- Your average RT for each task (A, B, C)
- Calculated categorization time (Task B - Task A)
- Calculated mental arithmetic time (Task C - Task B)
- Your raw data CSV file from the experiment

6.3 Lab Questions

Complete the following questions based on your lab experience and the assigned reading:

Download Questions

📋 Download Lab Questions (TXT)

Question 1: Donders' Subtraction Method (2 points)

Explain how Donders' subtraction method allows researchers to isolate specific mental processes. Using your own experimental data, calculate and interpret your categorization time and mental arithmetic time. What do these values represent in terms of cognitive processing?

Question 2: Hick's Law Application (2 points)

Based on your understanding of Hick's law, predict how reaction times would change if Task B included 8 number choices instead of 2 (odd/even). Explain your reasoning using the logarithmic relationship described in Hick's law, and discuss how this relates to information processing demands.

Question 3: Real-World Motor Control Applications (2 points)

Describe a specific sport or motor skill situation where understanding action preparation time would be critical for performance. Explain how the number of response choices, stimulus-response compatibility, or movement complexity might influence an athlete's reaction time in your chosen example.

Question 4: Premotor vs. Motor Components (2 points)

The textbook describes how RT can be fractionated into premotor and motor components. Based on your experimental results, explain which component (premotor or motor) would likely show the greatest change when comparing Task A to Task C. Justify your answer by describing what processes occur during each component.

Question 5: Factors Affecting Action Preparation (2 points)

Identify and explain three factors from Chapter 8 that could influence action preparation time in your daily activities. For each factor, provide a specific example of how it might affect your RT in a real-world situation (e.g., driving, sports, cooking, etc.).

6.4 Grading Criteria

ℹ Participation and Completion

Part 1 (In-Class): Participation points for completing data collection
Part 2 (At-Home): Graded submission based on question responses

Component	Points	Criteria
Question 1	2	Accurate explanation of subtraction method and data interpretation
Question 2	2	Correct application of Hick's law with clear reasoning
Question 3	2	Relevant motor skill example with thoughtful analysis
Question 4	2	Understanding of RT components and changes across tasks
Question 5	2	Three clear examples with accurate explanations
Total	**10**	*Based on Part 2 at-home submission*

7 Additional Resources

7.1 Related Concepts for Further Study

- Psychological Refractory Period (PRP)
- Stimulus-Response Compatibility Effects
- Vigilance and Sustained Attention
- Motor Programming Theory

7.2 Troubleshooting

If you experience technical difficulties:

1. Try refreshing your browser
2. Ensure JavaScript is enabled
3. Use Chrome, Firefox, or Edge for best compatibility
4. Contact the instructor if problems persist

Bibliography

Aditya331/Donders_reaction_time. (2025). https://github.com/Aditya331/Donders_reaction_time

Donders, F. (1969). On the speed of mental processes. *Acta Psychologica*, *30*, 412–431. https://doi.org/10.1016/0001-6918(69)90065-1

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Magill, R., & Anderson, D. I. (2017). *Motor learning and control: concepts and applications* (Eleventh edition). McGraw-Hill Education.