Data Analytics

Subqueries in SQL

GENERAL ASSEMBLY

Our Learning Goals

- Construct subqueries for multi-step operations.
- Identify subquery use cases for various business scenarios.

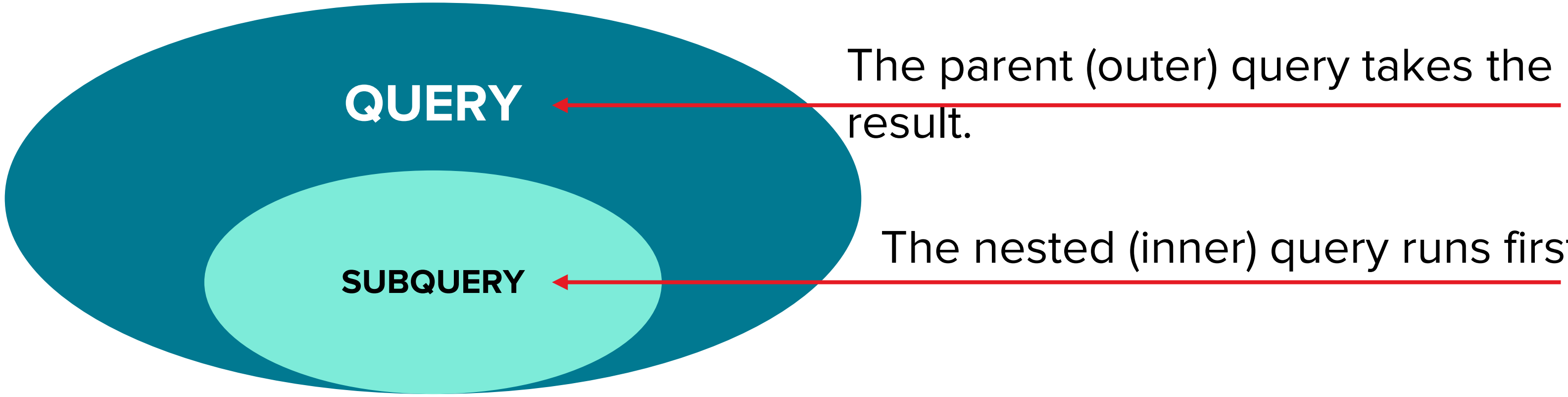
Subqueries in SQL

Introduction to Subqueries

Meet Subqueries

Also known as a **nested query**, a subquery is an SQL statement that combines multiple questions into one query.

How this works: When you run one query and get a result, you can feed it to another query.



The parent (outer) query takes the result.

The nested (inner) query runs first.

Discussion:

Cost of Returns

The VP of Operations at Superstore needs to determine the operational cost of shipping wrong items to customers. To help her make this critical decision, you've been asked to find out the following:

What is the number of orders (with wrong items) that have been returned for each shipping mode?

Writing queries is all about asking the right questions.

What are two questions we need to answer in order to write this query?

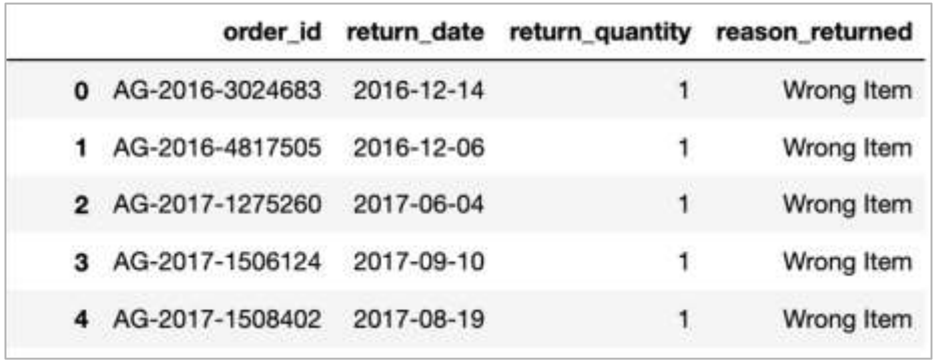
Pseudo-Coding Subqueries

Referring back to the request from the VP of Operations, we need to:

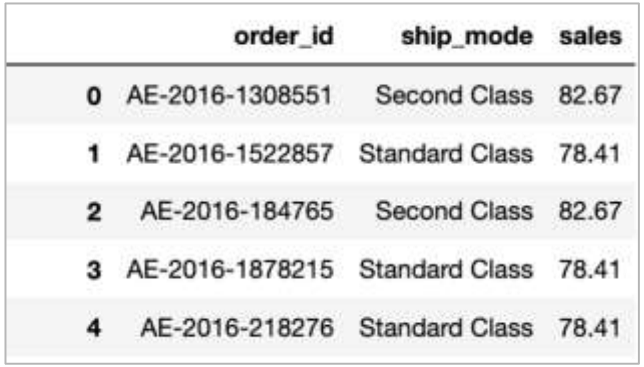
- Identify the order numbers that have been returned as "wrong item."
- Count the number of returned orders by each shipping mode.

Table: Returns

Table: Orders (select columns)



	order_id	return_date	return_quantity	reason_returned
0	AG-2016-3024683	2016-12-14	1	Wrong Item
1	AG-2016-4817505	2016-12-06	1	Wrong Item
2	AG-2017-1275260	2017-06-04	1	Wrong Item
3	AG-2017-1506124	2017-09-10	1	Wrong Item
4	AG-2017-1508402	2017-08-19	1	Wrong Item



	order_id	ship_mode	sales
0	AE-2016-1308551	Second Class	82.67
1	AE-2016-1522857	Standard Class	78.41
2	AE-2016-184765	Second Class	82.67
3	AE-2016-1878215	Standard Class	78.41
4	AE-2016-218276	Standard Class	78.41

Guided Walk-Through:

Subquery Syntax

```
SELECT ship_mode, COUNT( * )
FROM Orders
WHERE order_id IN (

     SELECT order_id
     FROM returns
     WHERE reason_returned =
                  “Wrong Item”

                   )
GROUP BY ship_mode;
```

A breakdown of the subquery (in red):

- **SELECT** all of the order_ids.
- FROM the **Returns** table, because we want to identify orders that match our criteria for return reason.
- Filter the results for only order_ids with reason_returned equal to “Wrong Item.”

Guided Walk-Through:

Subquery Syntax

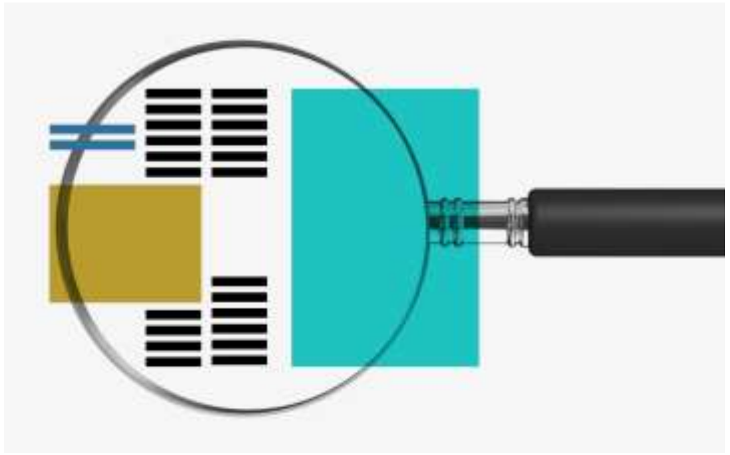
```
SELECT ship_mode, COUNT( * )
FROM Orders
WHERE order_id IN (

     SELECT order_id
     FROM returns
     WHERE reason_returned =
                 “Wrong Item”

                  )
GROUP BY ship_mode;
```

A breakdown of the outer query (in red) that reads the results from the inner query:

- **SELECT** takes ship_mode and a count of all rows.
- **FROM** tells us where the information is coming from.
- **WHERE** filters the selected rows from the Orders table using the results of our subquery.
- **GROUP BY** ship_mode because of our aggregation function COUNT.

Subquery Syntax | A Checklist

- ❏ Subqueries are enclosed in parentheses and will execute first.
- ❏ In order to execute, subquery structures **must** have complete query components: **SELECT**, **FROM**, and a specified criteria.
- ❏ Assigning aliases is important for syntax and readability.



Why Do You Need Subqueries...

...when you already have JOINs?

Subqueries and JOINs are both used to combine data from different tables.

Subqueries:

- Can be used to return either a single value or a row set.
- Can run on their own (as queries).
- Results are used immediately.
- Used in SELECT, WHERE, FROM, and HAVING.

JOINs:

- Used to return rows.
- Cannot run on their own.
- The “JOINed” results are available in SELECT statements.
- Used as FROM clauses of WHERE statements.

Source: Essential SQL

Subqueries in SQL

Subquery Types

Types of Subqueries

The three types of subqueries differ by how the results are used by the outer query: FROM, IN, or comparison.

Type 1: FROM statement uses the results of one query as a table for the *FROM statement* of the outer query.

Type 2: IN operator filters the results of one query by the results of another query using the *IN operator.*

Type 3: Comparison operator filters the results of one query by the results of another query using a *comparison operator.*

Type 1 Subquery Syntax

- Also known as “a query *within* a query,” it allows us to supply an entire query between parentheses as a subquery instead of calling a normal table.
- The outer query then treats result of the inner query as if it were a table.

```
SELECT a_column
FROM (SELECT another_column
         FROM a_different_table) AS alias;
```

Guided Walk-Through:

Type 1: A Table Within a Query

The Head of Sales asked for insights on whether we've seen an increase in average monthly sales over time. First, let's write a subquery to *calculate* the sales for every month:

```
SELECT DATE_TRUNC('month',order_date) as order_month,
SUM(sales) AS monthly_sales
FROM orders
GROUP BY 1;
```

Guided Walk-Through:

Type 1: A Table Within a Query (Cont.)

Then, average the results in the outer query:

```
SELECT DATE_PART(‘year’,order_month) AS year, AVG(monthly_sales) AS
avg_monthly_sales
FROM (SELECT DATE_TRUNC(‘month’,order_date) as order_month, SUM(sales)
AS monthly_sales
FROM orders
GROUP BY 1) AS temp
GROUP BY 1
ORDER BY 1 DESC;
```

Solo Exercise:

Categorizing Customers

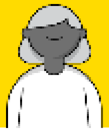
5 minutes

Most customers make several hundred purchases from us as a business supplier. Let's look at how much of our revenue these customers make up.

Inner query: Create a query that categorizes customers by purchase frequency and returns total sales per customer:

- 1000+ = Supplier
- 100+ = Multiple/ Frequent
- All others

Outer query: How much in sales did each segment make?



Solo Exercise:

Categorizing Customers | Solution

```
SELECT customer_type, SUM(total_sales) AS total_sales
FROM
    (SELECT customer_id,
    CASE WHEN COUNT(customer_id)>=1000 THEN 'Supplier'
    WHEN COUNT(customer_id)>=100 AND COUNT(customer_id) < 1000 THEN
    'Frequent’
    ELSE 'All others' END as customer_type,
        SUM(sales) as total_sales
    FROM orders
    GROUP BY 1) AS temp
GROUP BY 1
ORDER BY 2 DESC;
```

Type 2 Subquery Syntax

- The *inner query* retrieves a list of items in the form of **a single column**.
- The *outer query* then tests one of its columns against this list of items.

```
SELECT a_column
FROM a_table
WHERE column_id IN
    (SELECT column_id
         FROM a_different_table
     WHERE a_different_column meets some_condition);
```

Guided Walk-Through:

Type 2: IN Operator

Looking at orders in more detail, the VP of Product wants you to focus on the consumer segments and find out:

How many orders had products with a cost to consumer of more than $500?

First, write a query that first selects the appropriate products:

```
SELECT product_id
    FROM products
WHERE CAST(product_cost_to_consumer AS int) > 500;
```

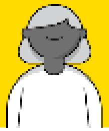
Then, insert it into the outer query's WHERE clause (see next slide).

Guided Walk-Through:

Type 2: IN Operator (Cont.)

```
SELECT COUNT(*)
FROM orders
WHERE product_id IN (
    SELECT product_id
        FROM products
    WHERE CAST(product_cost_to_consumer AS int) > 500);
```

Here, the inner query must *only* return **one column** for an **IN** filter. Consider that the inner query is *building an array of values* that are then substituted into the **WHERE** clause in the outer loop.



Solo Exercise:

How About **NOT IN**?

5 minutes

Conversely, you can use **NOT IN** in the subquery to exclude data.

Going back to the previous query, we can find the number of **orders that had products with a cost to consumer of more than $500** in either of two ways with the options below:

Give Option 2 a try, and we'll discuss as a class.

Option 1: Use the **IN** statement and the logical operator **greater than**.
Option 2: Use the **NOT IN** statement and the logical operator **less than**.

Solo Exercise:

How Did It Go? | Solutions

Query 1 Use IN

```
SELECT COUNT(*)
FROM orders
WHERE product_id IN (
 SELECT product_id
 FROM products
 WHERE
 CAST(product_cost_to_consumer
 AS int) > 500)
```

Query 2 Use NOT IN

```
SELECT COUNT(*)
FROM orders
WHERE product_id
NOT IN (
 SELECT product_id
 FROM products
 WHERE
 CAST(product_cost_to_consumer
 AS int) < 500)
```

Type 3 Subquery Syntax

- The *inner query* retrieves **the average of another column** from a different table.
- The *outer query* then takes the inner query and uses it with a comparison operator to filter a list of values.

```
SELECT *
FROM a_table
WHERE a_column <
    (SELECT AVG(another_column)
        FROM a_different_table);
```

Guided Walk-Through:

Type 3: Comparison Operator

Now that you have a gauge on the number of orders for products that had a cost of more than $500 to the consumer, let's shift the focus to profit:

How many orders have more profit than the average product cost to consumer?

Use a subquery to *first* calculate the most expensive item to consumers:

```
SELECT AVG(CAST(product_cost_to_consumer AS int))
FROM products;
```

Guided Walk-Through:

Type 3: Comparison Operator (Cont.)

Then, apply the subquery in the outer query:

```
SELECT COUNT(*)
FROM orders
WHERE CAST(profit AS int) >
    (SELECT AVG(CAST(product_cost_to_consumer AS int))
     FROM products);
```

Solo Exercise:

Use SELECT to Find %

5 minutes

Let's take our query from earlier and **find the share of sales that each frequency of customer makes up**. Add a SELECT subquery in our outer query to find the total sum of all sales.

```
SELECT customer_type, SUM(total_sales) AS total_sales
FROM
     (SELECT customer_id,
     CASE WHEN COUNT(customer_id)>=1000 THEN 'Supplier'
     WHEN COUNT(customer_id)>=100 AND COUNT(customer_id) < 1000 THEN 'Frequent'
     ELSE 'All others' END as customer_type,
          SUM(sales) as total_sales
     FROM orders
     GROUP BY 1) AS temp
GROUP BY 1
ORDER BY 2 DESC;
```

Solo Exercise:

Use SELECT to Find % | Solution

```
SELECT customer_type, SUM(total_sales) AS total_sales,
 SUM(total_sales)::numeric/(SELECT SUM(sales) FROM orders)::numeric
 AS share_of_sales
FROM
     (SELECT customer_id,
     CASE WHEN COUNT(customer_id)>=1000 THEN 'Supplier'
     WHEN COUNT(customer_id)>=100 AND COUNT(customer_id) < 1000 THEN 'Frequent’
     ELSE 'All others' END as customer_type,
          SUM(sales) as total_sales
     FROM orders
     GROUP BY 1) AS temp
GROUP BY 1
ORDER BY 2 DESC;
```

Subqueries in SQL

Wrapping Up

Solo Exercise:

Optional Homework

Use subqueries to answer the following questions:

1. Has our organization sales grown over the years?
2. On average, what percent of salespeople make a sale each month?
3. What percent of all sales in the United States did returns make up in 2020?

Additional Resources

- “Using Subqueries in the Select Statement” by essentialSQL.com: https://goo.gl/GsfwAb
- “Writing Subqueries in SQL” by Mode Analytics: https://community.modeanalytics.com/sql/tutorial/sql-subqueries/
- Beginner SQL Tutorial: http://beginner-sql-tutorial.com/sql-subquery.htm

Appendix: Subqueries in SQL

Additional Subquery Use Cases

Running Multiple Queries at Once

Using the subqueries methodology, you can run multiple SELECT statements at once and get the results on the same screen.

The benefit: If you need fields from multiple data sources or from multiple parts of a single data set (e.g., for comparison).

What this looks like in practice:
Instead of separately running two SELECT statements, we can **wrap each SELECT statement in its own parentheses** to be evaluated separately in a common results pane.

Discussion:

Running Multiple Queries

The queries will be run at once on the same screen. Knowing that each SELECT statement is wrapped in its own parentheses, what else do you notice about these queries? And what can you anticipate seeing in the results? Share your answer with the class.

```
(SELECT COUNT(*)
 FROM orders
 WHERE product_id IN (
 SELECT product_id FROM products
 WHERE
  CAST(product_cost_to_consumer
  AS int) > 500) )
 AS query_1_result,
```

```
(SELECT COUNT(*)
 FROM orders
 WHERE product_id NOT IN (
 SELECT product_id FROM products
 WHERE
  CAST(product_cost_to_consumer
  AS int) < 500) )
 AS query_2_result
```

Guided Walk-Through:

Running Multiple Queries

```
(SELECT COUNT(*)
 FROM orders
 WHERE product_id IN (
 SELECT product_id FROM products
 WHERE
  CAST(product_cost_to_consumer
  AS int) > 500)) AS query_1_result,

(SELECT COUNT(*)
 FROM orders
 WHERE product_id NOT IN (
 SELECT product_id FROM products
 WHERE
  CAST(product_cost_to_consumer
  AS int) < 500)) AS query_2_result
```

On your screen, the queries will be stacked like this, and...

1. We have to start the query with a **SELECT** statement.
2. Each query is wrapped in its own parentheses.
3. Each subquery is separated by a single comma.
4. **Alias** each query to keep track of the results.

Using CASE Statements in Subqueries

CASE statements can be used in *both* the inner query and outer queries.

What makes it cool? One useful and common construction is to:

- Use the inner (nested) query to create a binary value, sometimes called a "flag."
- Then, use the outer query to average that value.

Let's build an example using a **CASE** classification and a binary value!

Guided Walk-Through:

CASE in Subqueries

Let’s say we classified profit per order as small, medium, large. Now we want to use those categories to count how many orders fit into each group. Let’s look at the first classification query:

```
SELECT order_id, profit,
        CASE
        WHEN CAST(profit AS int) >= 1000 THEN 'large'
        WHEN CAST(profit AS int) >= 50 THEN 'medium'
        ELSE 'small'
    END AS profit_size
FROM orders
```

Guided Walk-Through:

CASE in Subqueries (Cont.)

Here is the first query (in red) serving as our inner query, with the outer query counting occurrences:

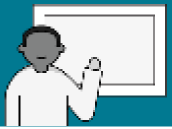
```
SELECT profit_size, COUNT(*) AS number_orders
FROM (SELECT order_id, profit,
        CASE
            WHEN CAST(profit AS int) >= 1000 THEN 'large'
            WHEN CAST(profit AS int) >= 50 THEN 'medium'
            ELSE 'small'
        END AS profit_size
        FROM orders) AS temp
GROUP BY profit_size;
```

Guided Walk-Through:

CASE in Subqueries With a Binary Value

Imagine you want to get even more granular and find out, ***by product_id*, what percentage of discounts were more than 25%**. First, create the inner query that classifies each discount as either more or less than 25%:

```
SELECT ship_mode, profit,
    CASE
        WHEN CAST(discount AS float) > 0.25 THEN 1
        ELSE 0
    END AS over_25
FROM orders;
```



Guided Walk-Through:

CASE in Subqueries With a Binary Value (Cont.)

Now, wrap query in an outer query that averages the *flag (binary value)* per store:

```
SELECT product_id, ROUND(AVG(over_25), 4) AS pct_over_25
FROM (SELECT product_id, profit,
                CASE WHEN CAST(discount AS float) > 0.25 THEN 1
               ELSE 0
                END AS over_25
      FROM orders) AS temp
GROUP BY product_id
ORDER BY product_id
LIMIT 100;
```

CTE in SQL

Appendix:
Common Table Expressions (CTE)

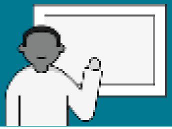
What to Do When...

Your queries are starting to look like this:

```
SELECT
(t3.segment || ': ' || t3.customer_name) AS customer_description,
(t2.sub_category || ', ' || t2.product_name) AS product_description,
(CAST(t1.quantity AS INTEGER)
    * CAST(t2.product_cost_to_consumer AS INTEGER)
    * (1 - CAST(t1.discount AS NUMERIC))) AS estimated_profit, EXTRACT(YEAR FROM
order_date) AS order_year
FROM orders AS t1
INNER JOIN products AS t2 ON t1.product_id = t2.product_id
INNER JOIN customers AS t3 ON t1.customer_id = t3.customer_id
WHERE estimated_profit < 100
```

Meet Common Table Expressions (CTE)

- A technique for creating a temporary result set that can be referenced within the following statements: **SELECT**, **INSERT**, **UPDATE**, or **DELETE**.
- CTEs are defined *outside* of the above statements using the **WITH** operator, making it a convenient way to manage more complicated queries.



Guided Walk-Through:

How to Create a CTE

After identifying the percentage of discounts by *product_id,* your Head of Sales now wants you to look at another factor that is affecting the overall profit:

Which customers are buying which products across all of our fiscal years with an estimated profit <$100?

Here is the basic main/outer query using CTE:

```
SELECT *
FROM t1_cte AS t1
INNER JOIN t2_cte AS t2 ON ...
INNER JOIN t3_cte AS t3 ON ...
WHERE some_criteria
```

Guided Walk-Through:

How to Create a CTE (Cont.)

To keep your results organized and easy to read, add a CTE.

```
WITH
t1_cte (col_1, col_2, ...) AS (query1 ...),
t2_cte (col_a, col_b, ...) AS (query2 ...),
t3_cte (col_x, col_y, ...) AS (query3 ...)
```

Common table expressions (CTEs) consist of two parts:

- Table expression definition
- Query definition

```
SELECT *
FROM t1_cte AS t1
INNER JOIN t2_cte AS t2 ON ...
INNER JOIN t3_cte AS t3 ON ...
WHERE some_criteria
```

Main query using CTE

Now Your Query Looks Like This!

```
WITH
 t1_cte (order_year, quantity, discount, product_id, customer_id) AS (
  SELECT EXTRACT(YEAR FROM TIMESTAMP order_date) AS order_year, quantity,
  discount, product_id, customer_id FROM orders),
 t2_cte (product_description, product_cost_to_consumer, product_id) AS (
  SELECT (sub_category || ', ' || product_name) AS product_description,
  product_cost_to_consumer, product_id FROM products),
 t3_cte (customer_description, customer_id) AS (
  SELECT (segment || ": " || customer_name) AS customer_description,
  customer_id FROM customers)

SELECT customer_description, product_description, order_year,
 (CAST(quantity AS INTEGER) * CAST(product_cost_to_consumer AS INTEGER)
  * (1 - CAST(discount AS DOUBLE))) AS estimated_profit
FROM t1_cte AS t1
INNER JOIN t2_cte AS t2 ON t1.product_id = t2.product_id
INNER JOIN t3_cte AS t3 ON t1.customer_id = t3.customer_id
WHERE estimated_profit < 100
```

Discussion:

How to Create Multiple CTEs

As it turns out, another analyst already wrote a query with multiple CTEs. Take a look at the code below. Together, let's describe what this query will execute.

```
WITH return_cte AS
                              (SELECT order_id, reason_returned
                FROM returns
                WHERE reason_returned NOT LIKE ‘Not Given’),
      order_cte AS
               (SELECT order_id, sales
                               FROM orders)

SELECT order_cte.order_id, order_cte.sales,
          return_cte. reason_returned
FROM return_cte INNER JOIN order_cte
ON return_cte.order_id = order_cte.order_id
LIMIT 100;
```

Benefits of Using CTEs

- **Readability:** Option to create chunks of data that would then be combined in a final SELECT statement.
- **Substitute for a View:** Use when you don't have permission to create a view object or the view would only be used in this one query.
- **Limitations:** Overcome SELECT statement limitations, such as referencing itself (recursion) or performing GROUP BY using a scalar subselect or non-deterministic functions.