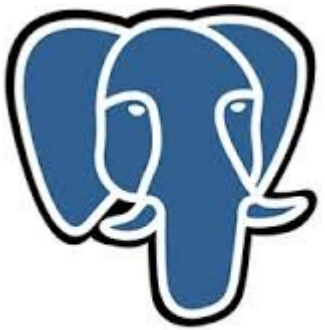
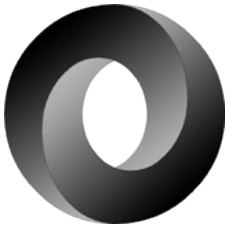
JSON by the other elephant



PostgreSQL

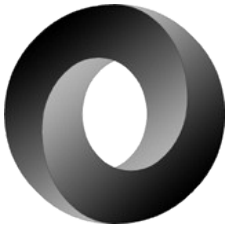
FOSDEM PGDay
January 2016
Stefanie Janine Stölting
@sjstoelting

JSON



- JavaScript Object Notation
- Don't have to care about encoding, it is always Unicode, most implemantations use UTF8
- Used for data exchange in web application
- Currently two standards RFC 7159 by Douglas Crockford und ECMA-404
- PostgreSQL impementation is RFC 7159

JSON Datatypes



JSON

Available since 9.2

BSON

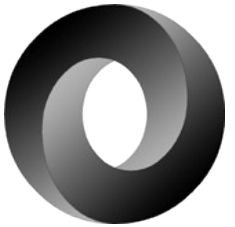
Available as extension on GitHub since 2013

JSONB

Available since 9.4

Crompessed JSON

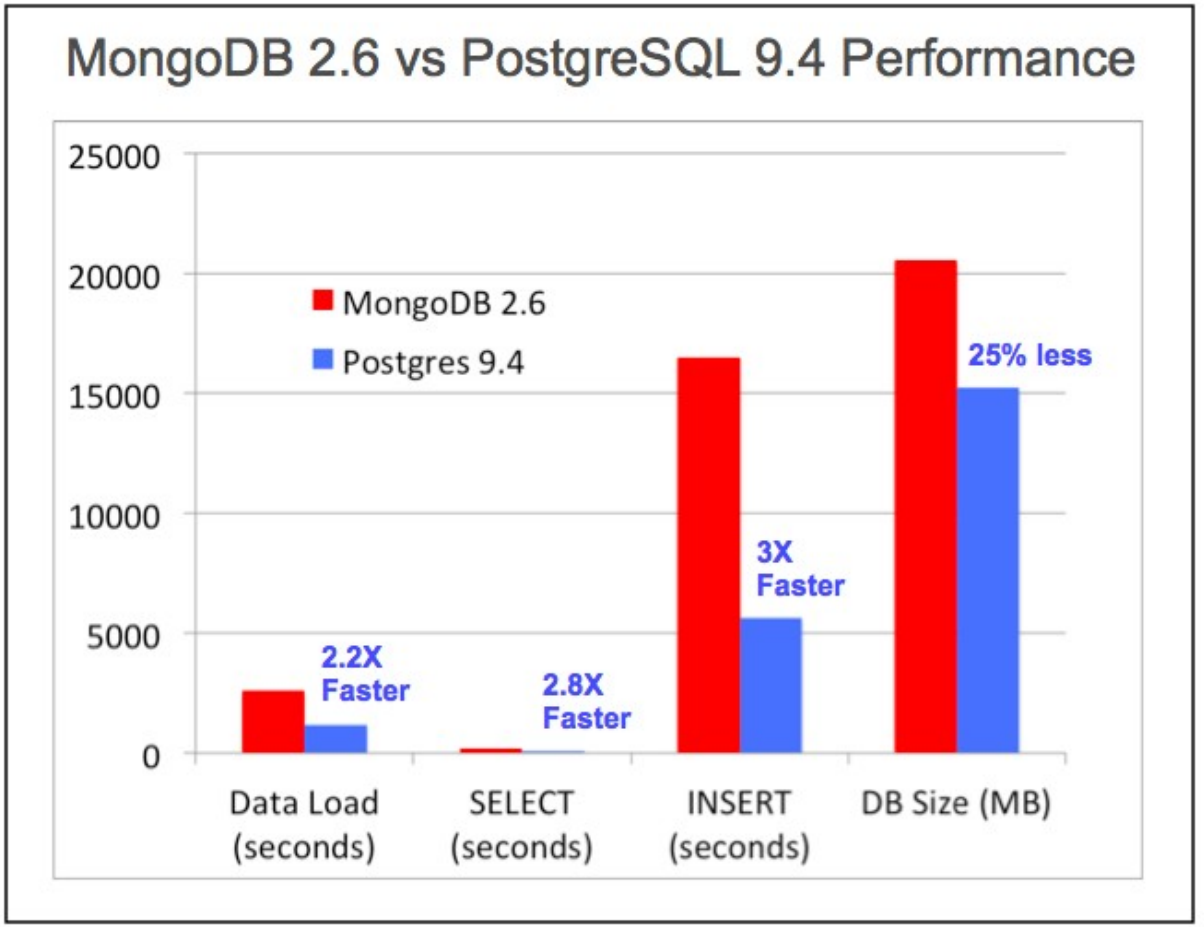
ACID



Atomicity, Consistency, Isolation, Durability is a set of properties that guarantee that database transactions are processed reliably. [1]

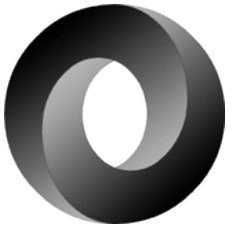
1 See https://en.wikipedia.org/wiki/ACID

Performance



Test done by EnterpriseDB, see the articleby Marc Linster

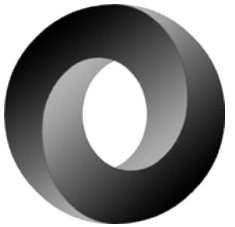
JSON Functions



row_to_json({row})
Returns the row as JSON

array_to_json({array})
Returns the array as JSON

JSON Opertators



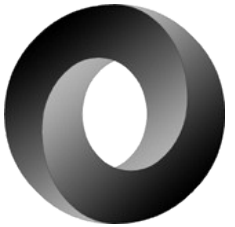
Array element
->{int}

Array element by name
->{text}

Object element
->> {text}

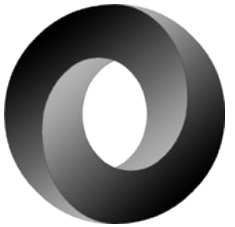
Value at path
#> {text}

Index on JSON



- Index JSONB content for faster access with indexes
  - GIN index overall
    - CREATE INDEX idx_1 ON jsonb.actor USING GIN (jsondata);
  - Even unique B-Tree indexes are possible
    - CREATE UNIQUE INDEX actor_id_2 ON jsonb.actor((CAST(jsondata->>'actor_id' AS INTEGER)));

New JSON functions

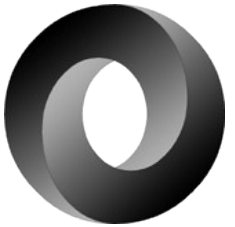


PostgreSQL 9.5 new JSONB functions:

- jsonb_pretty
- jsonb_set

Available as extions for 9.4 at PGXN: jsonbx

Data sources



The Chinook database is available at chinookdatabase.codeplex.com

Amazon book reviews of 1998 are available at examples.citusdata.com/customer_reviews_nested_1998.json.gz

Chinook Tables

	tablename
1	Artist
2	Invoice
3	Employee
4	Customer
5	Playlist
6	InvoiceLine
7	Album
8	Genre
9	PlaylistTrack
10	MediaType
11	Track

	table_name	column_name	data_type
1	Artist	ArtistId	integer
2	Artist	Name	character varying (120)

	table_name	column_name	data_type
1	Album	AlbumId	integer
2	Album	Title	character varying (160)
3	Album	ArtistId	integer

	table_name	column_name	data_type
1	Track	TrackId	integer
2	Track	Name	character varying (200)
3	Track	AlbumId	integer
4	Track	MediaTypeId	integer
5	Track	GenreId	integer
6	Track	Composer	character varying (220)
7	Track	Milliseconds	integer
8	Track	Bytes	integer
9	Track	UnitPrice	numeric

CTE

Common Table Expressions will be used in examples

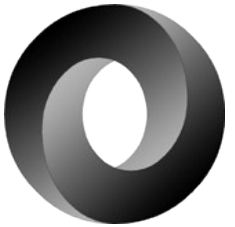
- Example:

```
WITH RECURSIVE t(n) AS (
    VALUES (1)
  UNION ALL
    SELECT n+1 FROM t WHERE n < 100
)
SELECT sum(n), min(n), max(n) FROM t;
```

- Result:

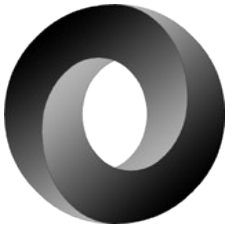
	sum bigint	min integer	max integer
1	5050	1	100

Live Examples



Let's see, how it does work.

Live with Chinook data

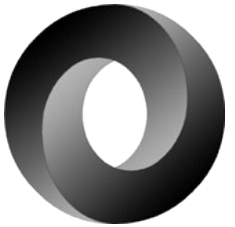


```
-- Step 1: Tracks as JSON with the album identifier
WITH tracks AS
    (
        SELECT "AlbumId" AS album_id
            , "TrackId" AS track_id
            , "Name" AS track_name
        FROM "Track"
    )
SELECT row_to_json(tracks) AS tracks
FROM tracks
;
```

	tracks
1	{"album_id":1,"track_id":1,"track_name":"For Those About To Rock (We Salute You)"}
2	{"album_id":2,"track_id":2,"track_name":"Balls to the Wall"}
3	{"album_id":3,"track_id":3,"track_name":"Fast As a Shark"}
4	{"album_id":3,"track_id":4,"track_name":"Restless and Wild"}
5	{"album_id":3,"track_id":5,"track_name":"Princess of the Dawn"}
6	{"album_id":1,"track_id":6,"track_name":"Put The Finger On You"}
7	{"album_id":1,"track_id":7,"track_name":"Let's Get It Up"}

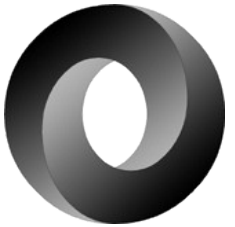
200 row(s) fetched - 7ms Grid

Live with Chinook data



```
-- Step 2 Abums including tracks with aritst identifier
WITH tracks AS
    (
        SELECT "AlbumId" AS album_id
            , "TrackId" AS track_id
            , "Name" AS track_name
        FROM "Track"
    )
, json_tracks AS
    (
        SELECT row_to_json(tracks) AS tracks
        FROM tracks
    )
, albums AS
    (
        SELECT a."ArtistId" AS artist_id
            , a."AlbumId" AS album_id
            , a."Title" AS album_title
            , array_agg(t.tracks) AS album_tracks
        FROM "Album" AS a
            INNER JOIN json_tracks AS t
            ON a."AlbumId" = (t.tracks->>'album_id')::int
        GROUP BY a."ArtistId"
            , a."AlbumId"
            , a."Title"
    )
SELECT artist_id
    , array_agg(row_to_json(albums)) AS album
FROM albums
GROUP BY artist_id
;
```

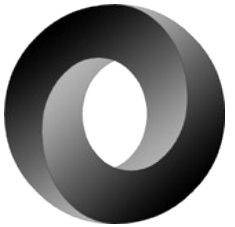
Live with Chinook data



	artist_id	album
1	251	{"artist_id":251,"album_id":319,"album_title":"Armada: Music from the Courts of England and Spain","albu
2	120	{"artist_id":120,"album_id":183,"album_title":"Dark Side Of The Moon","album_tracks":[{"album_id":183,"tr
3	227	{"artist_id":227,"album_id":293,"album_title":"Pavarotti's Opera Made Easy","album_tracks":[{"album_id":2
4	8	'{"artist_id":8,"album_id":271,"album_title":"Revelations","album_tracks":[{"album_id":271,"track_id":3389,"
5	247	{"artist_id":247,"album_id":314,"album_title":"English Renaissance","album_tracks":[{"album_id":314,"track
6	138	{"artist_id":138,"album_id":211,"album_title":"The Singles","album_tracks":[{"album_id":211,"track_id":2591
7	242	{"artist_id":242,"album_id":307,"album_title":"Adams, John: The Chairman Dances","album_tracks":[{"albur

168 row(s) fetched - 38ms Grid

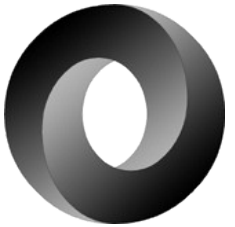
Live with Chinook data



```
-- Step 3 Return one row for an artist with all albums as VIEW
CREATE OR REPLACE VIEW v_json_artist_data AS
WITH tracks AS
    (
        SELECT "AlbumId" AS album_id
            , "TrackId" AS track_id
            , "Name" AS track_name
        FROM "Track"
    )
, json_tracks AS
    (
        SELECT row_to_json(tracks) AS tracks
        FROM tracks
    )
, albums AS
    (
        SELECT a."ArtistId" AS artist_id
            , a."AlbumId" AS album_id
            , a."Title" AS album_title
            , array_agg(t.tracks) AS album_tracks
        FROM "Album" AS a
            INNER JOIN json_tracks AS t
                ON a."AlbumId" = (t.tracks->>'album_id')::int
        GROUP BY a."ArtistId"
            , a."AlbumId"
            , a."Title"
    )
, json_albums AS
    (
        SELECT artist_id
            , array_agg(row_to_json(albums)) AS album
        FROM albums
        GROUP BY artist_id
    )

-- -> Next page
```

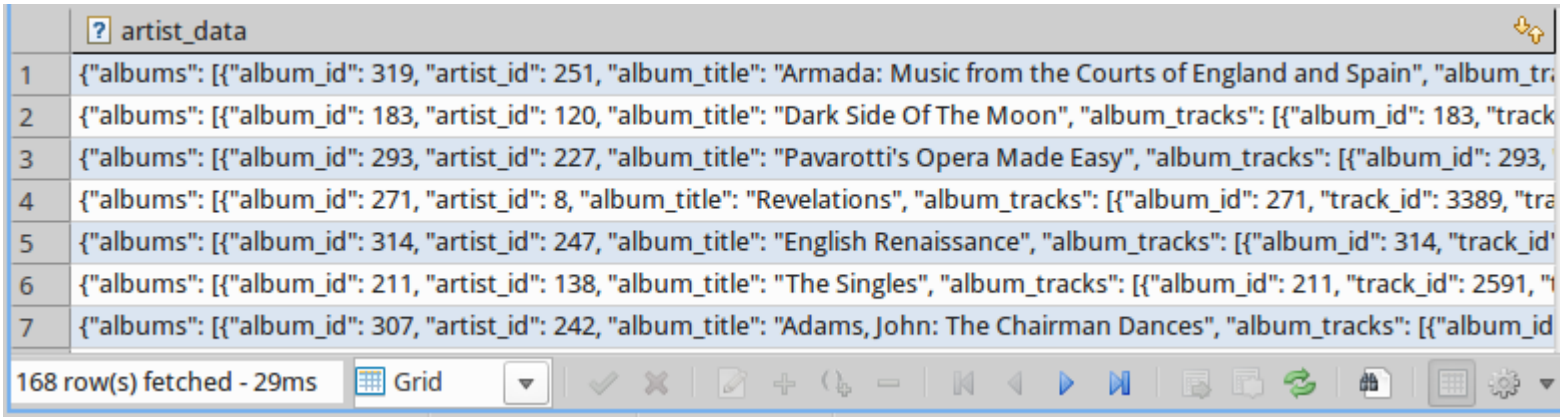
Live with Chinook data



```
-- Step 3 Return one row for an artist with all albums as VIEW
, artists AS
    (
        SELECT a."ArtistId" AS artist_id
            , a."Name" AS artist
            , jsa.album AS albums
        FROM "Artist" AS a
            INNER JOIN json_albums AS jsa
                ON a."ArtistId" = jsa.artist_id
    )
SELECT (row_to_json(artists))::jsonb AS artist_data
FROM artists
;
```

Live with Chinook data

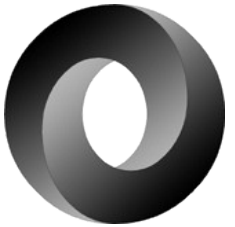
```
-- Select data from the view
SELECT *
FROM v_json_artist_data
;
```



	artist_data
1	{"albums": [{"album_id": 319, "artist_id": 251, "album_title": "Armada: Music from the Courts of England and Spain", "album_tr
2	{"albums": [{"album_id": 183, "artist_id": 120, "album_title": "Dark Side Of The Moon", "album_tracks": [{"album_id": 183, "track
3	{"albums": [{"album_id": 293, "artist_id": 227, "album_title": "Pavarotti's Opera Made Easy", "album_tracks": [{"album_id": 293,
4	{"albums": [{"album_id": 271, "artist_id": 8, "album_title": "Revelations", "album_tracks": [{"album_id": 271, "track_id": 3389, "tra
5	{"albums": [{"album_id": 314, "artist_id": 247, "album_title": "English Renaissance", "album_tracks": [{"album_id": 314, "track_id"
6	{"albums": [{"album_id": 211, "artist_id": 138, "album_title": "The Singles", "album_tracks": [{"album_id": 211, "track_id": 2591, "
7	{"albums": [{"album_id": 307, "artist_id": 242, "album_title": "Adams, John: The Chairman Dances", "album_tracks": [{"album_id

168 row(s) fetched - 29ms Grid

Live with Chinook data



```
-- SELECT data from that VIEW, that does querying
SELECT jsonb_pretty(artist_data)
FROM v_json_artist_data
WHERE artist_data->>'artist' IN ('Miles Davis', 'AC/DC')
;
```

jsonb_pretty

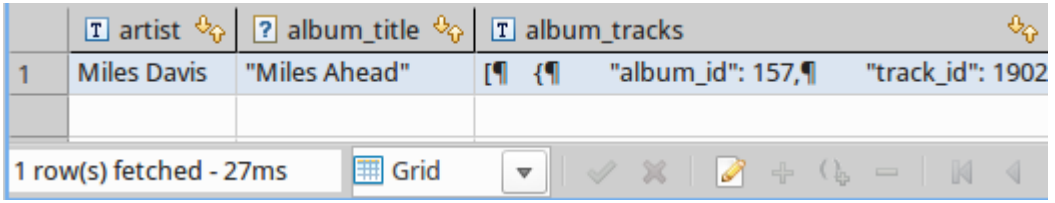
```
1 {¶  "albums": ¶  [¶  {¶  "album_id": 4,¶  "artist_id": 1,¶  "album_title": "Let There Be Rock",¶  "album_
2 {¶  "albums": ¶  [¶  {¶  "album_id": 48,¶  "artis                                              al Miles Davis [Disc 1]"
```

```
{
  "albums":
  [
    {
      "album_id": 4,
      "artist_id": 1,
      "album_title": "Let There Be Rock",
      "album_tracks":
      [
        {
          "album_id": 4,
          "track_id": 15,
          "track_name": "Go Down"
        },
        {
          "album_id": 4,
          "track_id": 16,
          "track_name": "Dog Eat Dog"
        },
        {
          "album_id": 4,
```

2 row(s) fetched - 25ms Grid

Live with Chinook data

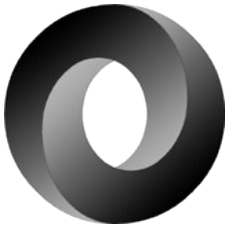
```
-- SELECT some data from that VIEW using JSON methods
SELECT artist_data->>'artist' AS artist
    , artist_data#>'{albums, 1, album_title}' AS album_title
    , jsonb_pretty(artist_data#>'{albums, 1, album_tracks}') AS album_tracks
FROM v_json_artist_data
WHERE artist_data->'albums' @> '[{"album_title":"Miles Ahead"}]'
;
```



	artist	album_title	album_tracks
1	Miles Davis	"Miles Ahead"	[¶ {¶ "album_id": 157,¶ "track_id": 1902

1 row(s) fetched - 27ms Grid

Live with Chinook data

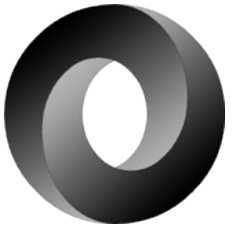


```
-- Array to records
SELECT artist_data->>'artist_id' AS artist_id
    , artist_data->>'artist' AS artist
    , jsonb_array_elements(artist_data#>'{albums}')->>'album_title' AS album_title
    , jsonb_array_elements(jsonb_array_elements(artist_data#>'{albums}')#>'{album_tracks}')->>'track_name' AS song_titles
FROM v_json_artist_data
WHERE artist_data->>'artist' = 'Metallica'
ORDER BY 3
;
```

	artist_id	artist	album_title	song_titles
1	50	Metallica	...And Justice For All	Last Caress/Green Hell
2	50	Metallica	...And Justice For All	Hit The Lights
3	50	Metallica	...And Justice For All	The Prince
4	50	Metallica	...And Justice For All	Bleeding Me
5	50	Metallica	...And Justice For All	Low Man's Lyric
6	50	Metallica	...And Justice For All	The Frayed Ends Of Sanity
7	50	Metallica	...And Justice For All	Sad But True
8	50	Metallica	...And Justice For All	Fight Fire With Fire
9	50	Metallica	...And Justice For All	The Wait
10	50	Metallica	...And Justice For All	Ronnie
11	50	Metallica	...And Justice For All	Trapped Under Ice
12	50	Metallica	...And Justice For All	Purify
13	50	Metallica	...And Justice For All	(Anesthesia) Pulling Teeth
14	50	Metallica	...And Justice For All	Devil's Dance
15	50	Metallica	...And Justice For All	Turn The Page
16	50	Metallica	...And Justice For All	St. Anger
17	50	Metallica	...And Justice For All	Stone Dead Forever
18	50	Metallica	...And Justice For All	Astronomy
19	50	Metallica	...And Justice For All	The Unforgiven
20	50	Metallica	...And Justice For All	Poor Twisted Me

200 row(s) fetched - 26ms Grid

Live with Chinook data



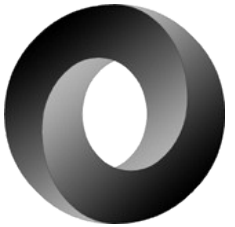
```
-- Create a function, which will be used for UPDATE on the view v_artrist_data
CREATE OR REPLACE FUNCTION trigger_v_json_artist_data_update()
    RETURNS trigger AS
$BODY$
    -- Data variables
    DECLARE rec               RECORD;
    -- Error variables
    DECLARE v_state           TEXT;
    DECLARE v_msg       TEXT;
    DECLARE v_detail    TEXT;
    DECLARE v_hint            TEXT;
    DECLARE v_context   TEXT;
BEGIN
    -- Update table Artist
    IF OLD.artist_data->>'artist' <> NEW.artist_data->>'artist' THEN
        UPDATE "Artist"
        SET "Name" = NEW.artist_data->>'artist'
        WHERE "ArtistId" = artist_data->>'artist_id';
    END IF;
-- Update table Album in a foreach
-- Update table Track in a foreach
RETURN NEW;

    EXCEPTION WHEN unique_violation THEN
        RAISE NOTICE 'Sorry, but the something went wrong while trying to update artist data';
        RETURN OLD;

    WHEN others THEN
        GET STACKED DIAGNOSTICS
            v_state = RETURNED_SQLSTATE,
            v_msg = MESSAGE_TEXT,
            v_detail = PG_EXCEPTION_DETAIL,
            v_hint = PG_EXCEPTION_HINT,
            v_context = PG_EXCEPTION_CONTEXT;

        RAISE NOTICE '%', v_msg;
        RETURN OLD;
END;
$BODY$
    LANGUAGE plpgsql;
```

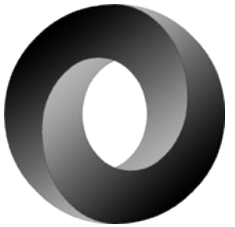
Live with Chinook data



Name	Value
	-- Create a function, which will be used for UPDATE on the view v_artrist_data CREATE OR REPLACE FUNCTION trigger_v_json_artist_data_update() RETURNS trigger AS $BODY$ -- Data variables DECLARE rec RECORD; -- Error variables DECLARE v_state TEXT; DECLARE v_msg TEXT; DECLARE v_detail TEXT;

1 row(s) fetched - 8ms | Grid

Live with Chinook data

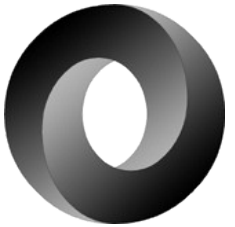


```
-- The trigger will be fired instead of an UPDATE statemen to save data
CREATE TRIGGER v_json_artist_data_instead_update INSTEAD OF UPDATE
    ON v_json_artist_data
    FOR EACH ROW
    EXECUTE PROCEDURE trigger_v_json_artist_data_update()
;
```

Name	Value
Query	-- The trigger will be fired instead of an UPDATE statemen to save data CREATE TRIGGER v_json_artist_data_instead_update INSTEAD OF UPDATE ON v_json_artist_data FOR EACH ROW EXECUTE PROCEDURE trigger_v_json_artist_data_update()
Updated Rows	0

1 row(s) fetched - 13ms Grid

Live with Chinook data



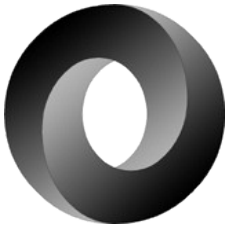
```
CREATE TABLE json_artist_data(
    id serial NOT NULL,
    artist_data JSONB NOT NULL,
    PRIMARY KEY (id)
)
;


-- Insert the data from the previously created view
INSERT INTO json_artist_data(artist_data)
SELECT artist_data
FROM v_json_artist_data
;
```

Name	Value
Query	-- Insert the data from the previously created view INSERT INTO json_artist_data(artist_data) SELECT artist_data FROM v_json_artist_data
Updated Rows	168

1 row(s) fetched - 40ms Grid

Live with Chinook data



```
-- Manipulate data with jsonb_set
SELECT artist_data->>'artist_id' AS artist_id
    , artist_data->>'artist' AS artist
    , jsonb_set(artist_data, '{artist}', '"Whatever we want, it is just text"'::jsonb)->>'artist' AS new_artist
FROM json_artist_data
WHERE (artist_data->>'artist_id')::int = 50
;
```

	artist_id	artist	new_artist
1	50	Metallica	Whatever we want, it is just text

1 row(s) fetched - 5ms Grid

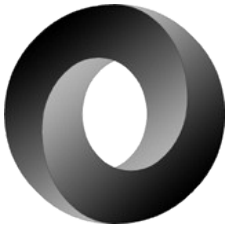
Live with Chinook data

```
-- Update a JSONB column with a jsonb_set result
UPDATE json_artist_data
SET artist_data= jsonb_set(artist_data, '{artist}', '"NEW Metallica"'::jsonb)
WHERE (artist_data->>'artist_id')::int = 50
;
```

Name	Value
Query	-- Update a JSONB column with a jsonb_set result UPDATE json_artist_data SET artist_data= jsonb_set(artist_data, '{artist}', '"NEW Metallica"'::jsonb) WHERE (artist_data->>'artist_id')::int = 50
Updated Rows	1

1 row(s) fetched - 20ms Grid

Live with Chinook data

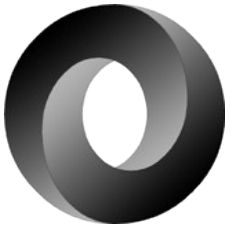


```
-- View the changes done by the UPDATE statement
SELECT artist_data->>'artist_id' AS artist_id
    , artist_data->>'artist' AS artist
FROM json_artist_data
WHERE (artist_data->>'artist_id')::int = 50
;
```

	artist_id	artist
1	50	NEW Metallica

1 row(s) fetched - 1ms Grid

Live with Chinook data

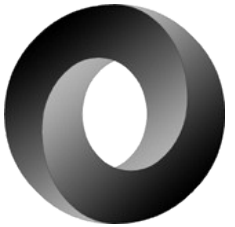


```
-- Manipulate data with the concatenating / overwrite operator
SELECT artist_data->>'artist_id' AS artist_id
    , artist_data->>'artist' AS artist
    , jsonb_set(artist_data, '{artist}', '"Whatever we want, it is just text"'::jsonb)->>'artist' AS new_artist
    , artist_data || '{"artist":"Metallica"}'::jsonb->>'artist' AS correct_name
FROM json_artist_data
WHERE (artist_data->>'artist_id')::int = 50
;
```

	artist_id	artist	new_artist	correct_name
1	50	NEW Metallica	Whatever we want, it is just text	Metallica

1 row(s) fetched - 6ms Grid

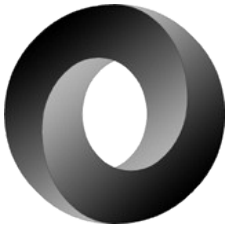
Live with Chinook data



```
-- Revert the name change of Metallica with in a different way: With the replace operator
UPDATE json_artist_data
SET artist_data = artist_data || '{"artist":"Metallica"}'::jsonb
WHERE (artist_data->>'artist_id')::int = 50
;
```

Name	Value
Query	-- Revert the name change of Metallica with in a different way: With the replace operator UPDATE json_artist_data SET artist_data = artist_data || '{"artist":"Metallica"}'::jsonb WHERE (artist_data->>'artist_id')::int = 50
Updated Rows	1

Live with Chinook data

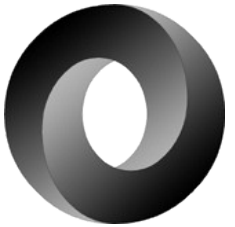


```
-- View the changes done by the UPDATE statement with the replace operator
SELECT artist_data->>'artist_id' AS artist_id
    , artist_data->>'artist' AS artist
FROM json_artist_data
WHERE (artist_data->>'artist_id')::int = 50
;
```

	artist_id	artist
1	50	Metallica

1 row(s) fetched - 5ms Grid

Live Amazon reviews

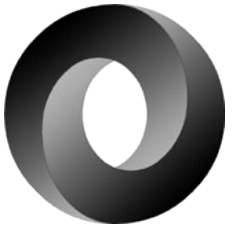


```
-- Create a table for JSON data with 1998 Amazon reviews
CREATE TABLE reviews(review_jsonb jsonb);
```

Name	Value
Query	CREATE TABLE reviews(review_jsonb jsonb)
Updated Rows	0

1 row(s) fetched - 32ms

Live Amazon reviews



```
-- Import customer reviews from a file
COPY reviews FROM '/var/tmp/customer_reviews_nested_1998.json'
```

Name	Value
Query	-- Import customer reviews from a file COPY reviews FROM '/var/tmp/customer_reviews_nested_1998.json'
Updated Rows	0

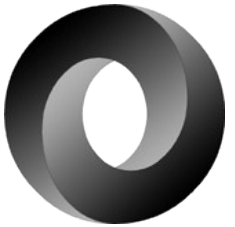
1 row(s) fetched - 10730ms

```
-- Maintenance the filled table
VACUUM ANALYZE reviews;
```

Name	Value
Query	-- Maintenance the filled table VACUUM ANALYZE reviews
Updated Rows	0

1 row(s) fetched - 2371ms

Live Amazon reviews

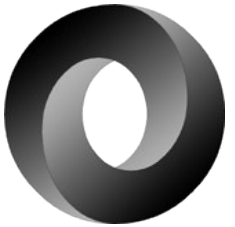


```
-- There should be 589.859 records imported into the table
SELECT count(*) FROM reviews;
```

	count
1	589.859

1 row(s) fetched - 104ms

Live Amazon reviews



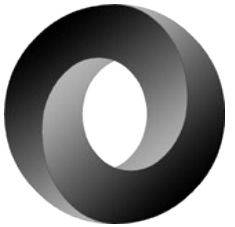
```
-- Select data with JSON
SELECT
    review_jsonb#>> '{product,title}' AS title
    , avg((review_jsonb#>> '{review,rating}')::int) AS average_rating
FROM reviews
WHERE review_jsonb@>'{"product": {"category": "Sheet Music & Scores"}}'
GROUP BY 1
ORDER BY 2 DESC
;
```

Without an Index: 248ms

	title	average_rating
1	Complete Works for Solo Keyboard	5
2	The Magic Flute (Die Zauberflote in Full Score)	5
3	Requiem in Full Score	5
4	The Four Seasons and Other Violin Concertos in Full Score	5
5	Symphony No. 3 (Dover Miniature Scores)	5

12 row(s) fetched - 248ms Grid

Live Amazon reviews



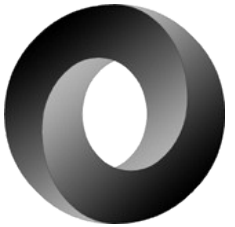
```
-- Create a GIN index
CREATE INDEX review_review_jsonb ON reviews USING GIN (review_jsonb);
```

Name	Value
Query	-- Create a GIN index CREATE INDEX review_review_jsonb ON reviews USING GIN (review_jsonb)
Updated Rows	0

1 row(s) fetched - 21079ms

Grid

Live Amazon reviews



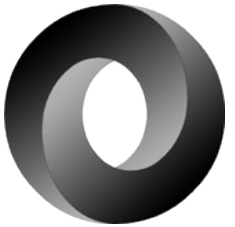
```
-- Select data with JSON
SELECT
    review_jsonb#>> '{product,title}' AS title
    , avg((review_jsonb#>> '{review,rating}')::int) AS average_rating
FROM reviews
WHERE review_jsonb@>'{"product": {"category": "Sheet Music & Scores"}}'
GROUP BY 1
ORDER BY 2 DESC
;
```

The same query as before with the previously created GIN Index: 7ms

	title	average_rating
1	Complete Works for Solo Keyboard	5
2	The Magic Flute (Die Zauberflote in Full Score)	5
3	Requiem in Full Score	5
4	The Four Seasons and Other Violin Concertos in Full Score	5
5	Symphony No. 3 (Dover Miniature Scores)	5

12 row(s) fetched - 7ms Grid

Live Amazon reviews



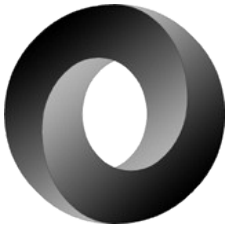
```
-- SELECT some statistics from the JSON data
SELECT  review_jsonb#>>'{product,category}' AS category
    , avg((review_jsonb#>>'{review,rating}')::int) AS average_rating
    , count((review_jsonb#>>'{review,rating}')::int) AS count_rating
FROM reviews
GROUP BY 1
;
```

Without an Index: 9747ms

	category	average_rating	count_rating
1		4,487	1.521
2	Accessories	4,703	37
3	Action & Adventure	4,261	3.938
4	African American Cinema	4,694	36
5	Alternative Rock	4,522	15.508

84 row(s) fetched - 9747ms Grid

Live Amazon reviews



```
-- Create a B-Tree index on a JSON expression
CREATE INDEX reviews_product_category ON reviews ((review_jsonb#>>'{product,category}'));
```

Name	Value
Query	-- Create a B-Tree index on a JSON expression CREATE INDEX reviews_product_category ON reviews ((review_jsonb#>>'{product,category}'))
Updated Rows	0

1 row(s) fetched - 11875ms

Grid

Live Amazon reviews

```
-- SELECT some statistics from the JSON data
SELECT  review_jsonb#>>'{product,category}' AS category
    , avg((review_jsonb#>>'{review,rating}')::int) AS average_rating
    , count((review_jsonb#>>'{review,rating}')::int) AS count_rating
FROM reviews
GROUP BY 1
;
```

The same query as before with the previously created BTREE Index: 1605ms

	category	average_rating	count_rating
1		4,487	1.521
2	Accessories	4,703	37
3	Action & Adventure	4,261	3.938
4	African American Cinema	4,694	36
5	Alternative Rock	4,522	15.508

84 row(s) fetched - 1605ms Grid

JSON by example