What is the breakdown of schema change in terms of the different types of change in schema evolution?

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1 Nomenclature and how to measure change

A Schema History is a list of commits (a.k.a. versions) of the same DDL file of a database schema, ordered over time. A transition from an older version i to its subsequent version i +1 occurs at the timepoint where version i +1 is committed, and potentially incurs changes in the schema. The initial, originating version of the history is called, as shorthand, V_s0. Active commits are the commits whose sum of updates (see next) exceeds zero. Non-Active commits involve changes in comments, directives to the DBMS, INSERT statements, indexing, and other changes that do not affect the logical capacity of the schema in terms of tables, attributes, data types or primary keys.

The Schema Update Period (SUP) is the time span (in human time) between the first and the last commit of the schema file. This is a very different time interval than its superset, Project Update Period (PUP) that marks the start and end of project history.

For each transition of the schema history, our tool, *Hecate*, automatically computes several categories of measurements. First, it computes timing information, like the distance of the i +1 commit from V_s0 in days, and the running month and year. Second, it registers the schema size (no. of tables, attributes) of both the older and the subsequent version of the transition.

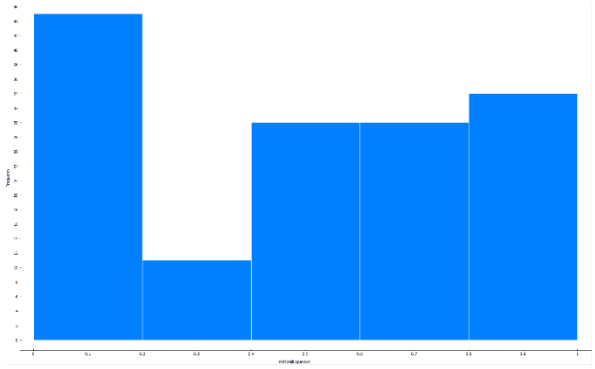
Third, Hecate identifies and quantifies updates (all measured in attributes):

- attributes born with a new table,
- attributes injected into an existing table,
- attributes deleted with a removed table,
- attributes ejected from a surviving table,
- attributes having a changed data type,
- attributes with participation in a changed primary key.

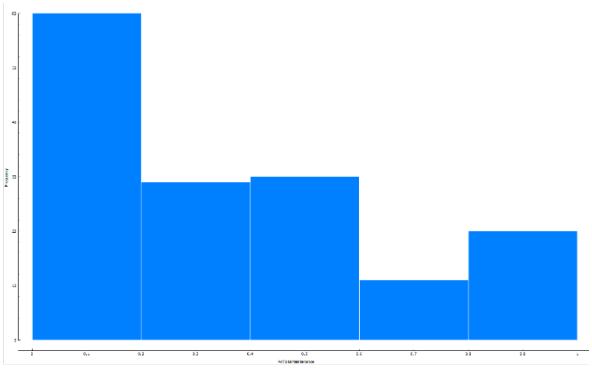
We measure as Expansion the sum of attributes born and injected, and as Maintenance, the sum of all the other categories. Total Activity, or simply Activity, of the schema, is the sum of Expansion and Maintenance. In what follows, remember that fundamental unit of measurement of change in our setting is the attribute, for all categories.

2 Breakdown of schema change

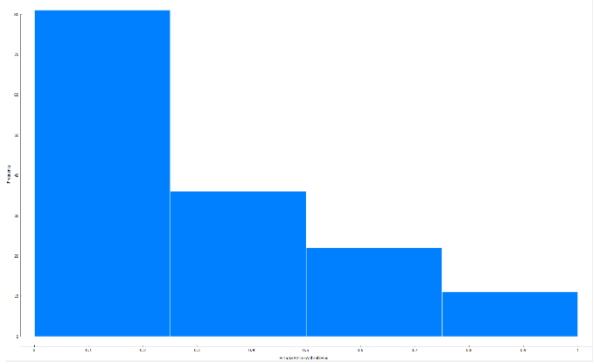
2.1 Change type breakdown without patterns being involved



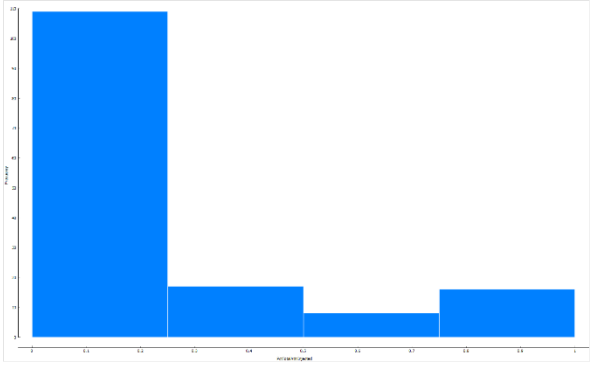
Expansion



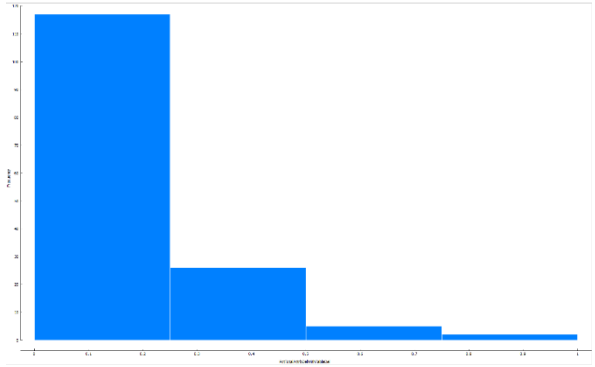
Maintenance



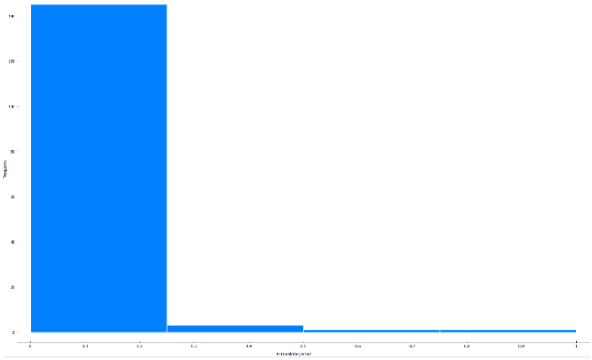
Born with Table Births



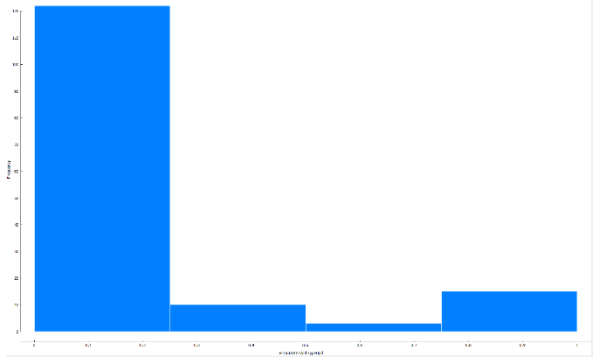
Injected in Existing Tables



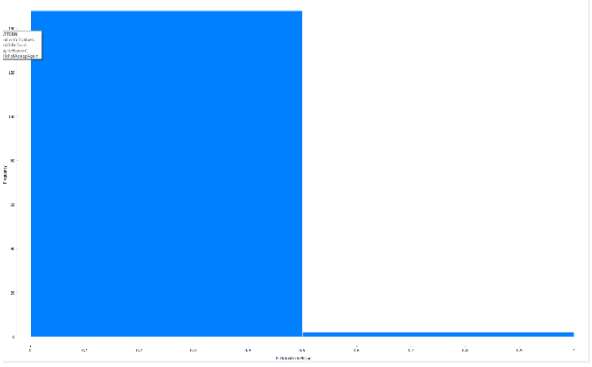
Deleted with table Deletion



Ejected from surviving tables



Data type maintenance



PK change

Figure 2.1 Histograms of the change types for the entire data set. X-axis in buckets of 0.25 within 0 to 1; Y-axis shows the number of projects for the respective bucket.

Figure 2.1 shows the histograms of the entire data set. The high numbers of the first bucket in all categories, clearly show the aversion to change.

2.2 Coarse overview of change breakdown via quartiles

For each project, we have computed how total change breaks down in the different categories of change, in both absolute and ratio numbers. Here we mainly work with ratio measures, as percentages, to better show the breakdown of change. For the population of each pattern, as well as for the entire corpus, we have computed the 25%, 50% (median) and 75% quartile for each change measure. Given any arbitrary population, the interpretation of this numbers is as follows: if the value of the 25% quartile for an activity measure is large, this means that there are few projects with small volume of activity of this type in the population; similarly, if the value of the 75% quartile is small, this means that most projects up to the 75% of the population have small activity value.

Note, however, that due to the presence of predominantly small values for most of the projects, even small numbers can lead to large percentages (e.g., for a schema with just one attribute injection in its entire life, attribute injection gets 100% of the activity). For projects with zero total activity, we assign all percentages as zero, in order to illustrate the fact in the respective statistics that we use – ignoring them would be worse, in our opinion).

Figure 2.2 presents the cardinality of the corpus of each quarter of the population and Figure 2.3 presents the respective bar charts. Figure 2.4 presents the values of the quartiles. The appendices contain the scatter-plots, box-plots and violin-plots of the data.

The breakdown of the **maintenance family of measures** is really revealing. Attributes ejected are rarely present and almost only for Regularly Curated and Smoking Funnel projects. People avoid ejecting attributes from existing tables in the general case. The avoidance of changes in Primary Keys is even more widespread. Table deletions are rather absent from the populous “Be Quick or be Dead family”, and mostly present in the two other families (overall, the median of their contribution to change is 0%, however). A little bit more widespread is the case of data type updates (empirically, we have observed that most of this change concerns enlarging VARCHAR fields), with a median of 2% in the entire data set. As we shall see later, these observations change if patterns are examined independently.

On the contrary, in all cases but sigmoid and late risers, expansion is mostly done with new tables (and less with attribute injections to existing ones). Again, this is the path of least resistance for both the maintenance of the code and the data migration. See the scatterplots in the Appendix too. Concerning the **expansion family of measures** (attributes injected to existing tables, attributes born with new tables and total expansion), we can state the following. The family of sharp, focused change typically has too many projects with 0% expansion (thus the low values in the Q1 quartile of 25% of the projects). However, these numbers are larger than the respective ones of maintenance, hence clearly stating that expansion is more frequent than maintenance. This is more evident for the first family of “be quick or be dead” projects (which is also much more voluminous too), and less evident for the other two families.

Interestingly, all these results are not fully in-sync with previous literature (cf. “References”) which has traditionally been based on very active projects, where evolution was amply evident. Previous research has been performed on selected projects, who, by selection, were demonstrating significant amounts of change. In our case, exactly due to the unbiased nature of the project selection process, large numbers of low-evolving projects were included, and thus, the numbers are different.

The result can be very useful for benchmark construction.

			Expansion				Maintenance			
		#	0.00-0.25	0.25-0.50	0.50-0.75	0.75-1.00	0.00-0.25	0.25-0.50	0.50-0.75	0.75-1.00
Be Quick	11_FlatLiner	*23*	16		3	4	14	4		5
or Be Dead	12_RadicalSign	*41*	9	9	9	14	20	9	9	3
	13_Sigmoid	*19*	10		3	6	14	2	1	2
	14_LateRiser	*14*	5	1	2	6	8	2	1	3
Stairway to	21_QuantumSteps	*23*	6	4	6	7	7	5	5	6
Heaven	22_RegularlyCurated	*14*		3	8	3	3	8	3	
Scared to Fall	31_SmokingFunnel	*7*		1	6			5	2	
Asleep Again	32_Siesta	*10*	1	6	3			3	6	1
		151	**47**	**24**	**40**	**40**	**66**	**38**	**27**	**20**

			Expansion				Maintenance			
		#	0.00-0.25	0.25-0.50	0.50-0.75	0.75-1.00	0.00-0.25	0.25-0.50	0.50-0.75	0.75-1.00
Be Quick	11_FlatLiner	*23*	**69.57%**	0.00%	13.04%	17.39%	**60.87%**	17.39%	0.00%	21.74%
or Be Dead	12_RadicalSign	*41*	21.95%	21.95%	21.95%	34.15%	48.78%	21.95%	21.95%	7.32%
	13_Sigmoid	*19*	**52.63%**	0.00%	15.79%	31.58%	**73.68%**	10.53%	5.26%	10.53%
	14_LateRiser	*14*	35.71%	7.14%	14.29%	42.86%	**57.14%**	14.29%	7.14%	21.43%
Stairway to	21_QuantumSteps	*23*	26.09%	17.39%	26.09%	30.43%	30.43%	21.74%	21.74%	26.09%
Heaven	22_RegularlyCurated	*14*	0.00%	21.43%	**57.14%**	21.43%	21.43%	**57.14%**	21.43%	0.00%
Scared to Fall	31_SmokingFunnel	*7*	0.00%	14.29%	**85.71%**	0.00%	0.00%	**71.43%**	28.57%	0.00%
Asleep Again	32_Siesta	*10*	10.00%	**60.00%**	30.00%	0.00%	0.00%	30.00%	**60.00%**	10.00%
		151	**31.13%**	**15.89%**	**26.49%**	**26.49%**	**43.71%**	**25.17%**	**17.88%**	**13.25%**

Figure 2.2 Breakdown of Change-Type in Quartiles as (a) absolute numbers ad (b) population percentages

Figure 2.3 Breakdown of Change-Type in Quartiles as (a) absolute numbers ad (b) population percentages as a bar chart

#prj	mega pattern	pattern	Total Expansion			Total Attr Ins With Table Ins			Total Attr Injected			Total Maintenance			Total Attr Del With Table Del			Total Attr Ejected			Total Attr With Type Upd			Total Attr In PK Upd		
			Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
23		**11_FlatLiner**	**0%**	**0%**	**61%**	0%	0%	0%	0%	0%	11%	**0%**	**0%**	**41%**	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%
41	1_Be Quick Or Be	**12_RadicalSign**	**36%**	**54%**	**91%**	0%	31%	54%	0%	11%	25%	**0%**	**26%**	**52%**	0%	0%	30%	0%	0%	5%	0%	0%	11%	0%	0%	0%
19	Dead	**13_Sigmoid**	**0%**	**6%**	**77%**	0%	0%	10%	0%	0%	39%	**0%**	**0%**	**29%**	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%
14		**14_LateRiser**	**0%**	**57%**	**100%**	0%	0%	35%	0%	13%	85%	**0%**	**0%**	**57%**	0%	0%	0%	0%	0%	0%	0%	0%	35%	0%	0%	0%
23	2_Stairway To	**21_QuantumSteps**	**26%**	**61%**	**81%**	0%	39%	48%	0%	14%	24%	**19%**	**39%**	**74%**	0%	0%	17%	0%	0%	9%	0%	12%	56%	0%	0%	0%
14	Heaven	**22_RegularlyCurated**	**51%**	**59%**	**70%**	31%	41%	56%	11%	15%	20%	**30%**	**41%**	**49%**	9%	21%	27%	3%	7%	12%	6%	10%	15%	0%	0%	0%
7	3_Scared To Fall	**31_SmokingFunnel**	**52%**	**58%**	**61%**	19%	32%	44%	11%	26%	37%	**39%**	**42%**	**48%**	13%	16%	28%	4%	7%	12%	4%	8%	17%	0%	0%	5%
10	Asleep Again	**32_Siesta**	**38%**	**46%**	**60%**	6%	32%	47%	3%	12%	26%	**40%**	**54%**	**63%**	0%	0%	43%	0%	3%	7%	6%	12%	44%	0%	0%	3%
151	**TOTAL**	**TOTAL**	**0%**	**51%**	**76%**	**0%**	**15%**	**48%**	**0%**	**11%**	**28%**	**0%**	**33%**	**55%**	**0%**	**0%**	**19%**	**0%**	**0%**	**7%**	**0%**	**2%**	**17%**	**0%**	**0%**	**0%**

Figure 2.4 Quartiles of Change-Type Breakdown

2.3 Change type breakdown per pattern

Based on the detailed data that we list in the Appendix on the change breakdown per change type, in Table 2.1, we present a **summary of the breakdown of change, for expansion and maintenance per pattern**. We divide the percentages in ranges, (a) treating a range of higher than 60% for an arbitrary category *C* as "*mostly C*", (b) treating values in the 40%-60% range as "middle level" mixture, and also, (c) isolate the special cases of 0% for a certain category, and, (d) of no *change* (0%,0%) whatsoever, too.

	Expansion	Maintenance	#prj	%prjs of pattern
11_FlatLiner	0%	0%	11	48%
23	0%	100%	5	22%
	(0%-40%)	(60%-100%)	0	0%
	middle	level	1	4%
	(60%-100%)	(0%-40%)	4	17%
	100%	0%	2	9%
12_RadicalSign	0%	0%	6	15%
41	0%	100%	1	2%
	(0%-40%)	(60%-100%)	6	15%
	middle	level	9	22%
	(60%-100%)	(0%-40%)	9	22%
	100%	0%	10	24%
13_Sigmoid	0%	0%	8	42%
19	0%	100%	1	5%
	(0%-40%)	(60%-100%)	1	5%
	middle	level	2	11%
	(60%-100%)	(0%-40%)	3	16%
	100%	0%	4	21%
14_LateRiser	0%	0%	2	14%
14	0%	100%	3	21%
	(0%-40%)	(60%-100%)	0	0%
	middle	level	2	14%
	(60%-100%)	(0%-40%)	1	7%
	100%	0%	6	43%
21_QuantumSteps	0%	0%	0	0%
23	0%	100%	4	17%
	(0%-40%)	(60%-100%)	4	17%
	middle	level	3	13%
	(60%-100%)	(0%-40%)	8	35%
	100%	0%	4	17%
22_RegularlyCurated	0%	0%	0	0%
14	0%	100%	0	0%
	(0%-40%)	(60%-100%)	0	0%
	middle	level	7	50%
	(60%-100%)	(0%-40%)	7	50%
	100%	0%	0	0%
31_SmokingFunnel	0%	0%	0	0%
7	0%	100%	0	0%
	(0%-40%)	(60%-100%)	0	0%
	middle	level	5	71%
	(60%-100%)	(0%-40%)	2	29%
	100%	0%	0	0%
32_Siesta	0%	0%	0	0%
10	0%	100%	1	10%
	(0%-40%)	(60%-100%)	2	20%
	middle	level	4	40%
	(60%-100%)	(0%-40%)	3	30%
	100%	0%	0	0%

Table 2.1 Summary of the breakdown of expansion and maintenance in ranges per pattern

The data reveal some important properties for each pattern which we discuss right away. We also introduce the following terminology:

- *Monothematic change* is change achieved via exactly one mega-type of change, i.e., expansion or maintenance.
- *Monotype change* is change achieved via exactly one of the 6 types of changes.

Flatliners. Flatliners are mostly projects of zero change. The rest of the projects in this pattern also have very small, almost zero, volumes of change. Ideally, one would expect flatliners having zero change entirely. However, some of them experience change within the first month after schema birth, and thus exhibit change, albeit not visually demonstrable. These projects are equally split in a maintenance only, and, mostly expansion. With exceptions, expansion is mostly achieved via attribute injections. Maintenance is mostly manifested via type updates. With few exceptions in the flatliners category, change is typically monothematic.

Radical sign. The radical sign pattern is the most populous among time-related patterns. It comes with the archetype pattern of "schema is born with or soon after project initiation; immediately after, some changes are applied to it; then, schema is frozen". The radical sign pattern is the most diverse in terms of internal mixture of change than all others. 6 projects have zero change whatsoever. With the exception of 14 projects (1/3 of the population of the pattern) of the radical sign pattern that are oriented towards maintenance, change is focused on two or three change types, mostly of expansion nature (12 projects are expansion only).

Radical sign change is predominantly achieved via table insertions and deletions. We conjecture that this is due to table and attribute renaming, which in our modeling is represented via deletions and insertions immediately after. Maintenance is mostly due to attribute deletion.

Moreover, there are six projects that hold total attribute injection as their change and nothing else. For the projects that are mostly inclined towards expansion, expansion via table birth is predominant. Also, for the projects that are mostly inclined towards expansion, change is frequently monothematic, if not monotype.

Sigmoid. Sigmoid is a category with projects that have mostly low change and are substantially monothematic. 8 out of 19 projects have no change whatsoever. 5 of the remaining 12 projects are monothematic. With few exceptions, change is small. Sigmoid projects are slightly inclined towards expansion. There is no maintenance really, except for two large projects with too many table deletions. Expansion is mostly due to attribute injections.

Late risers. Late risers are heavily monothematic (9 of 12 projects demonstrating some sort of change). They include projects with small change (with just one exception). The pattern is slightly biased towards expansion. Expansion is mostly due to attribute injections. In terms of maintenance, sigmoid has four projects with a stronger inclination to total maintenance, achieved mostly via type updates. In all other cases, maintenance is not existent: the rest of the projects are expansion-only projects, with very small change, manifested mainly via attribute injections.

Quantum Steps. The Quantum Steps pattern is mostly expansion-oriented. The pattern has four projects that are maintenance-only, with change manifested via type updates. In the projects of the pattern where maintenance is dominant, this is done mostly via update-type updates. In the projects of the pattern with a variety of change types, maintenance is mostly achieved via deletion of entire tables. Wherever expansion is predominant in this pattern, this is clearly done via new table births.

Regularly curated projects. This is also a time-related pattern with almost all categories appearing in almost all projects (with the exception of primary key updates). Change rises to significant volumes in the projects of this pattern. The mix of change is mostly balanced, slightly in favor of expansions. However, it is clear that, in the categories of Table 2.1 there are only two ranges hosting projects (equally divided): (a) those of balanced, middle-level bias, and, (b) of slight bias towards expansion. There is no project with bias in favor of maintenance whatsoever, and no monothematic projects either. Expansion is mostly achieved via new tables. Injections clearly exist but significantly less than attributes been born with new tables. Maintenance is mostly achieved via table deletions, with (i) attributes being ejected and (ii) data types being updated constituting a second tier of types in terms of popularity.

Smoking funnel. Smoking Funnel is a time-related pattern quite similar to the one of Regularly Curated projects, in terms of its change type breakdown, both with respect to expansion and maintenance. Again, almost all projects demonstrate change in almost all the categories of change, with a slight bias towards of expansion. Expansion in half the cases is mostly via table births and the other half of the cases is mostly via attribute injections. Maintenance is mostly achieved via table deletions with (i) attributes being ejected and (ii) data types being updated constituting a second tier of types in terms of population.

Siesta. Finally, siesta projects are also heavily mixed, with each project having a large number of change types (at least three of them) in its change mixture. In contrast to the other categories, siesta projects are slightly in favor of maintenance. Maintenance is split half and half between (a) table deletions and (b) data type updates. Expansion is mostly achieved via table insertions.

3 Conclusions

With the exception of few radical sign projects that are oriented towards maintenance, the "Be Quick or Be Dead" family involves small change, frequently being zero, and an inclination towards expansion. Due to the small volume of change, the patterns of the family are frequently monothematic in their internal breakdown of change types.

In contrast, the rest of the time-related patterns come with higher volumes of changes, which is also related to a variety of change types. Both expansion and maintenance are performed with the granule of change being mostly the entire table (being inserted or deleted), rather than the internal restructuring of existing tables.

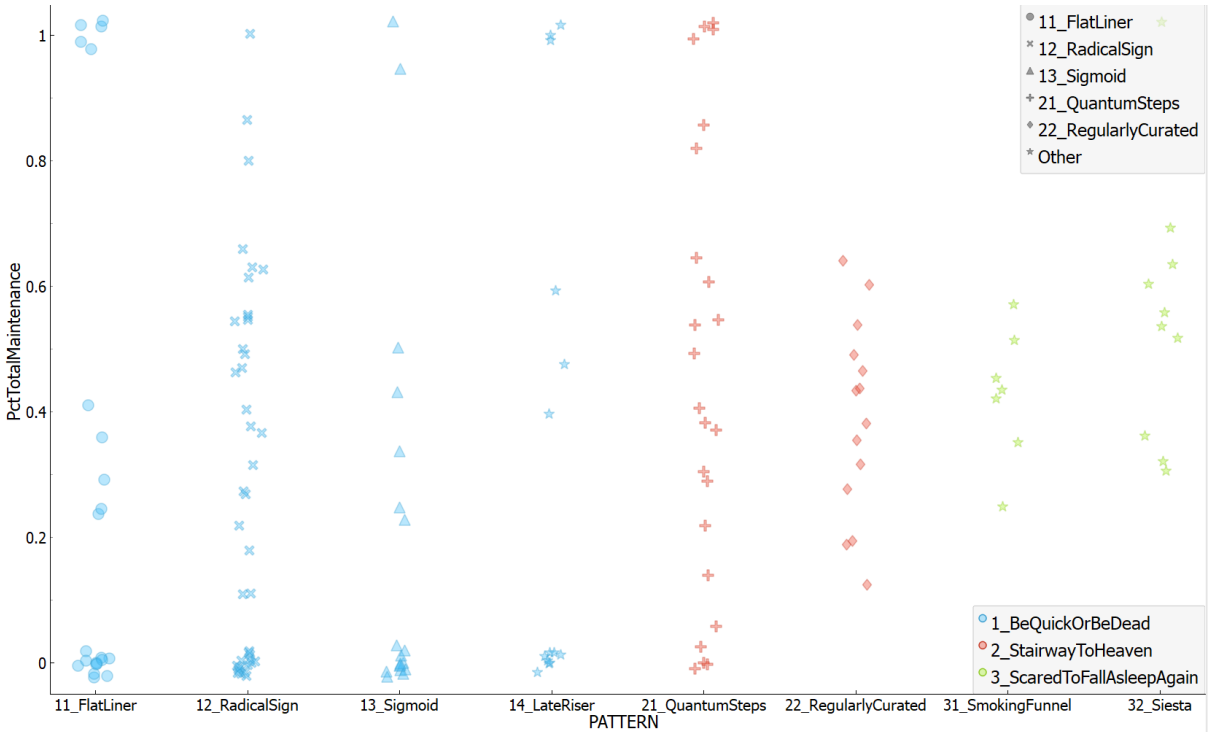
References

Curino, C.A., Tanca, L., Moon, H.J., Zaniolo, C. Schema evolution in wikipedia: toward a web information system benchmark. In: Proceedings of the ICEIS 2008

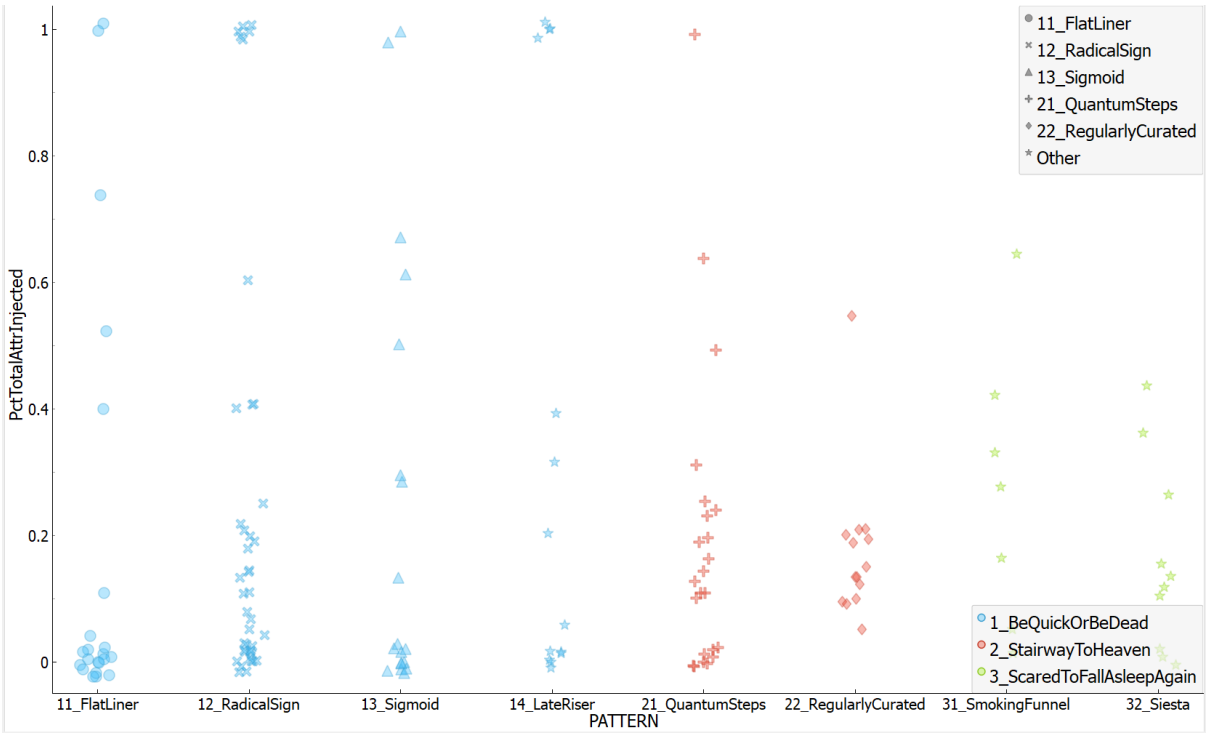
Mark Lukas Möller, Stefanie Scherzinger, Meike Klettke, Uta Störl. Why It Is Time for Yet Another Schema Evolution Benchmark - Visionary Paper. CAiSE Forum 2020: 113-125

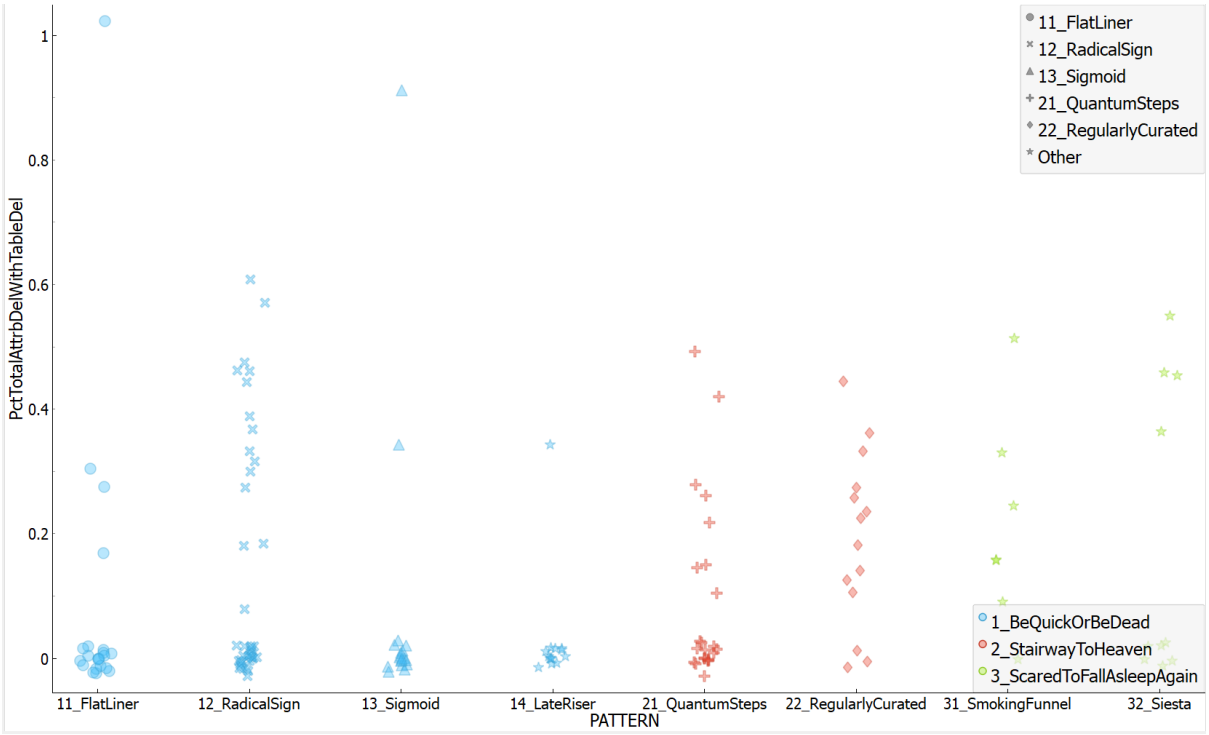
APPENDICES

4 Scatterplots for the different categories of change

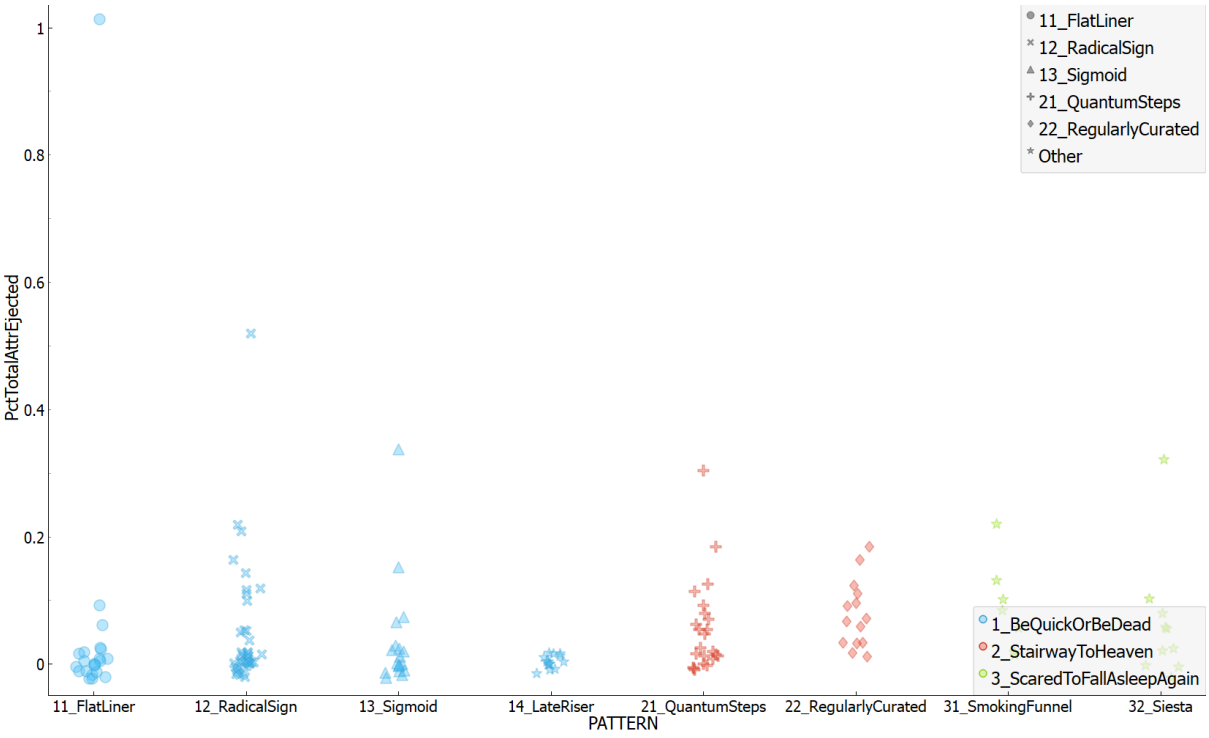


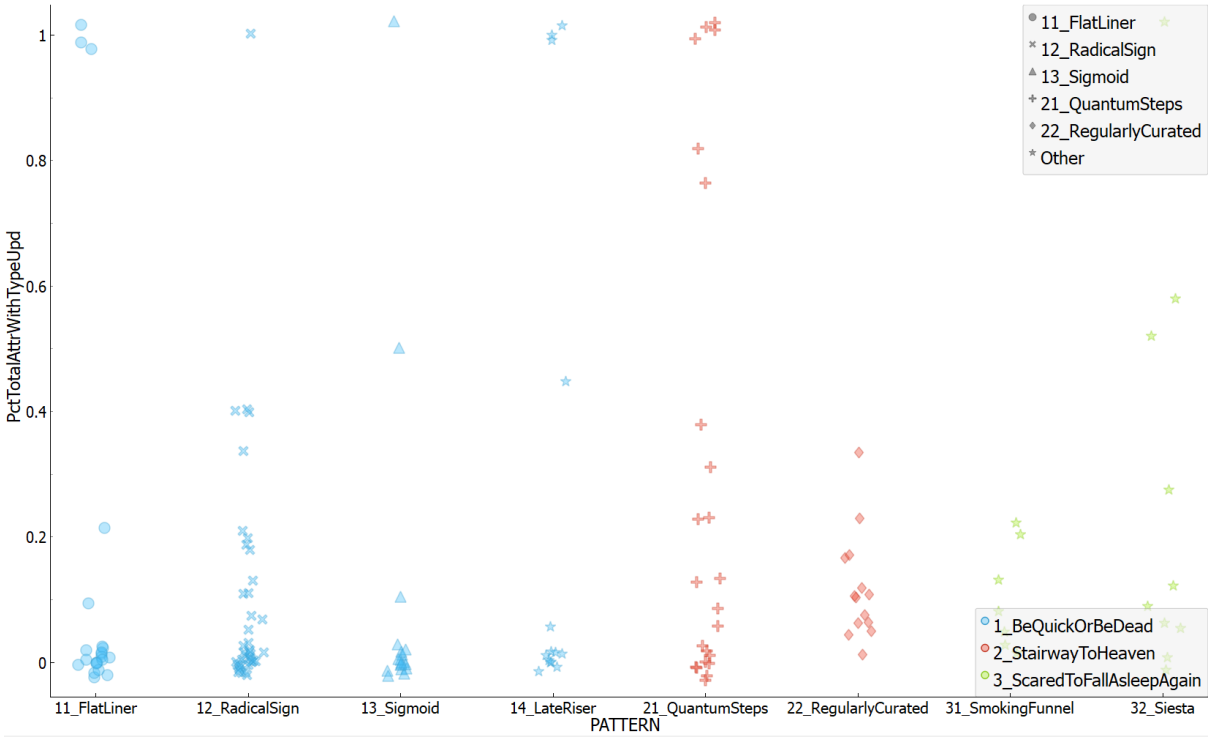
Contrast the two scatterplots: injection has (a) some “fanatics” of 100% and (b) otherwise lower levels of participation to total change compared to birth with new tables.



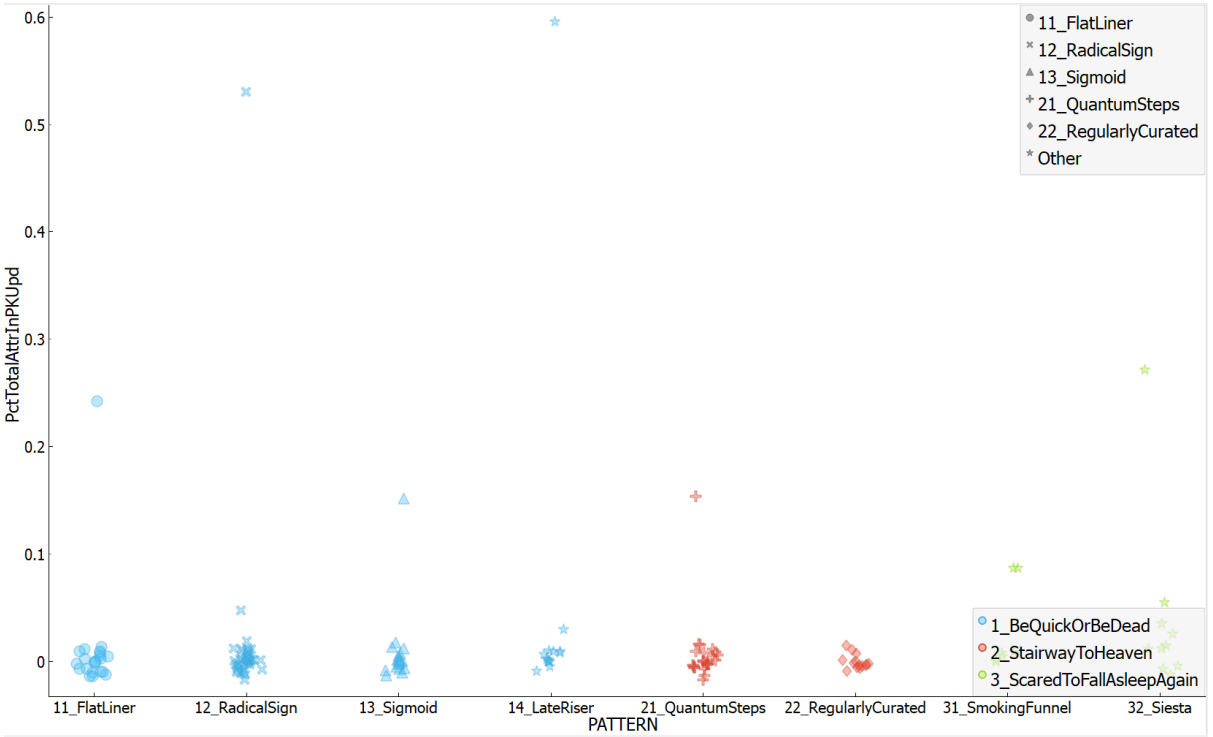


Contrast the two scatterplots: removal with entire tables is more popular than ejection from tables that continue to exist (very few cases surpass 20% of change due to ejection).





Data type changes has its “fanatics” of 100% (as well as many projects where it does not exist at all) and several projects where it exists in the 10% - 40%. PK change is practically inexistent.



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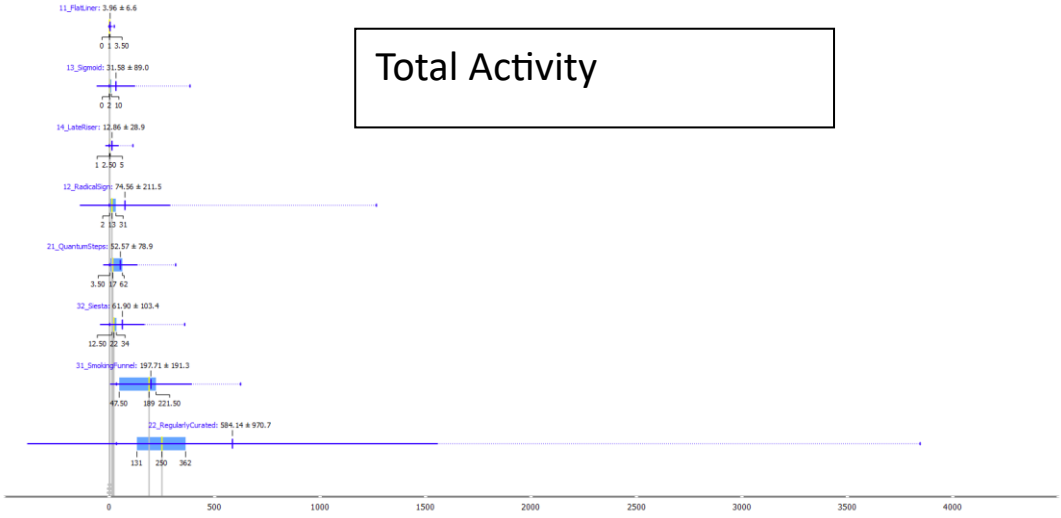
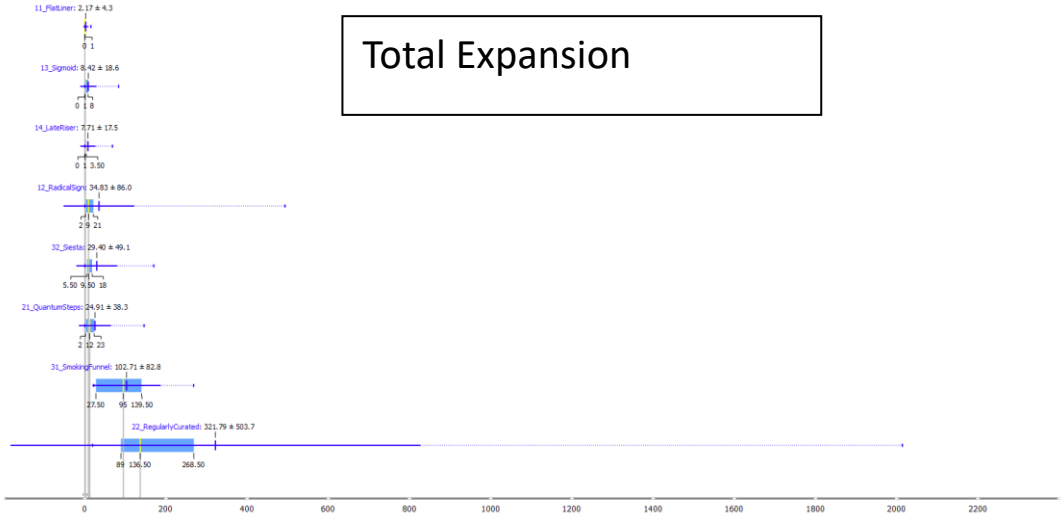
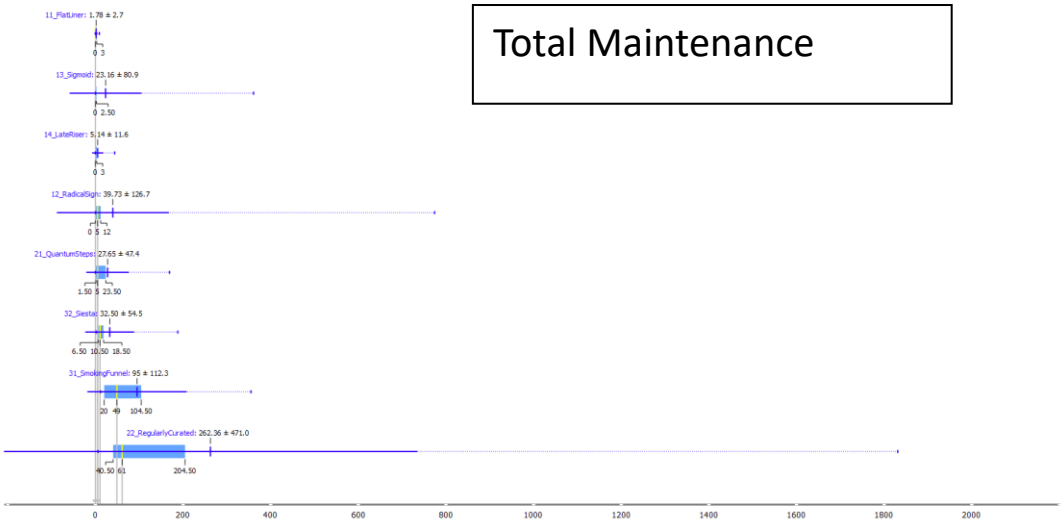
5 Box Plots of Absolute Values for the different Categories of Change



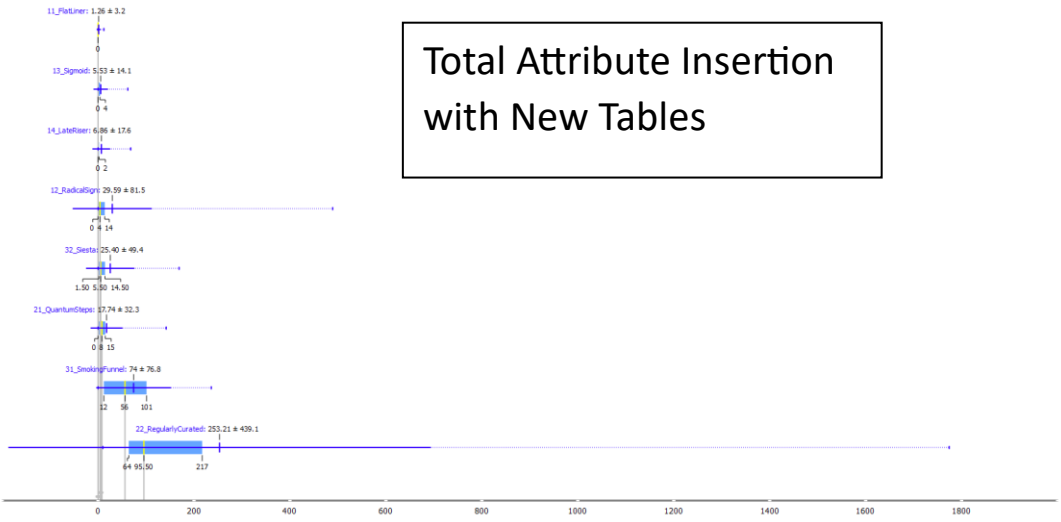
Total Activity



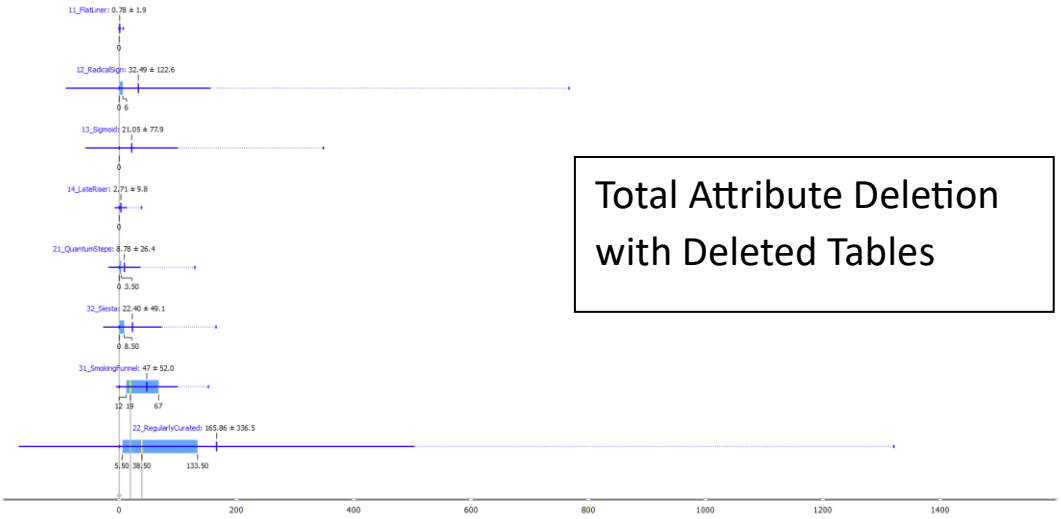
Total Expansion



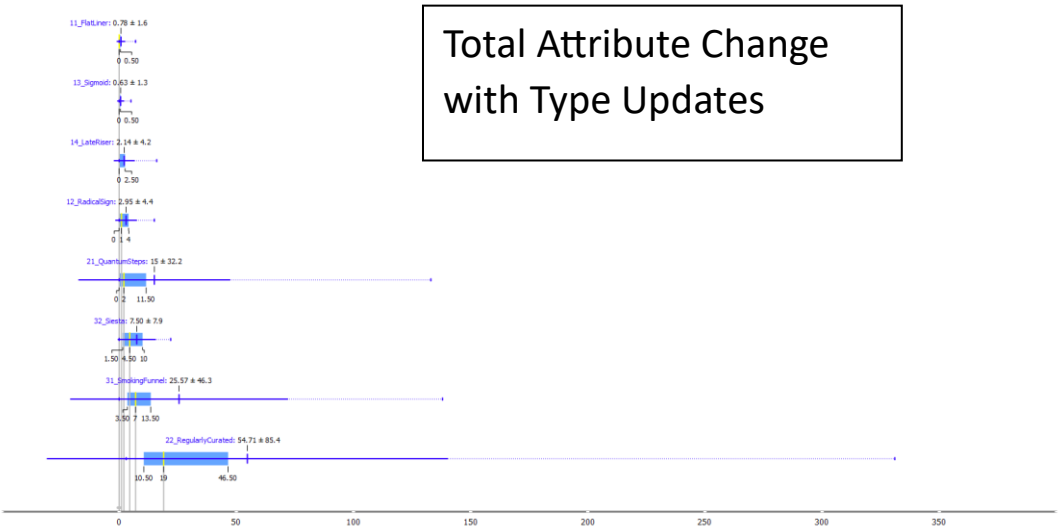
Total Maintenance



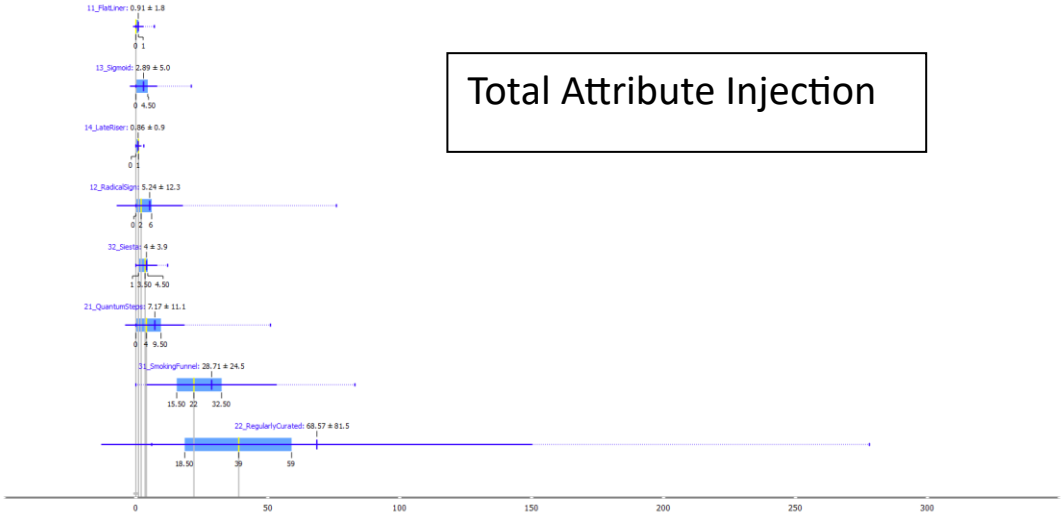
Total Attribute Insertion with New Tables



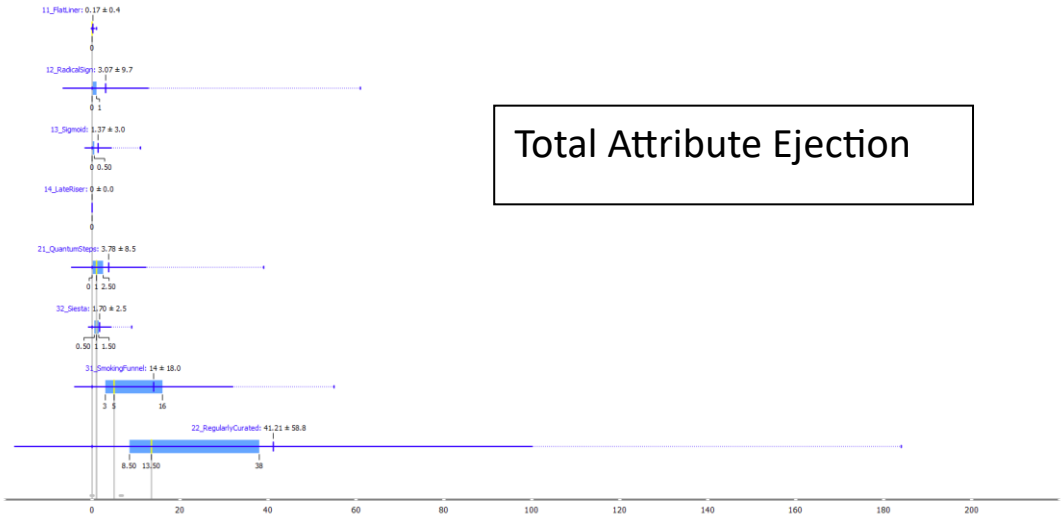
Total Attribute Deletion with Deleted Tables



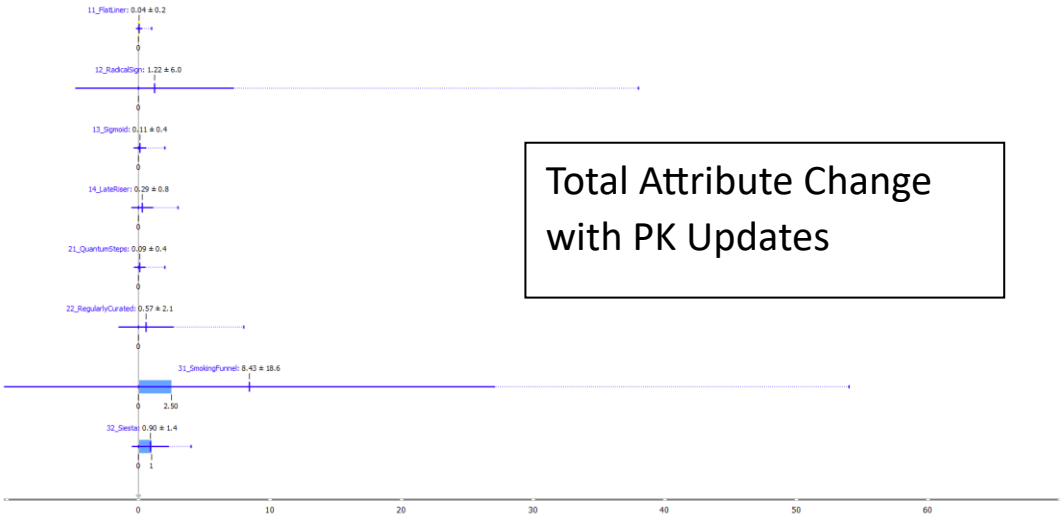
Total Attribute Change with Type Updates



Total Attribute Injection

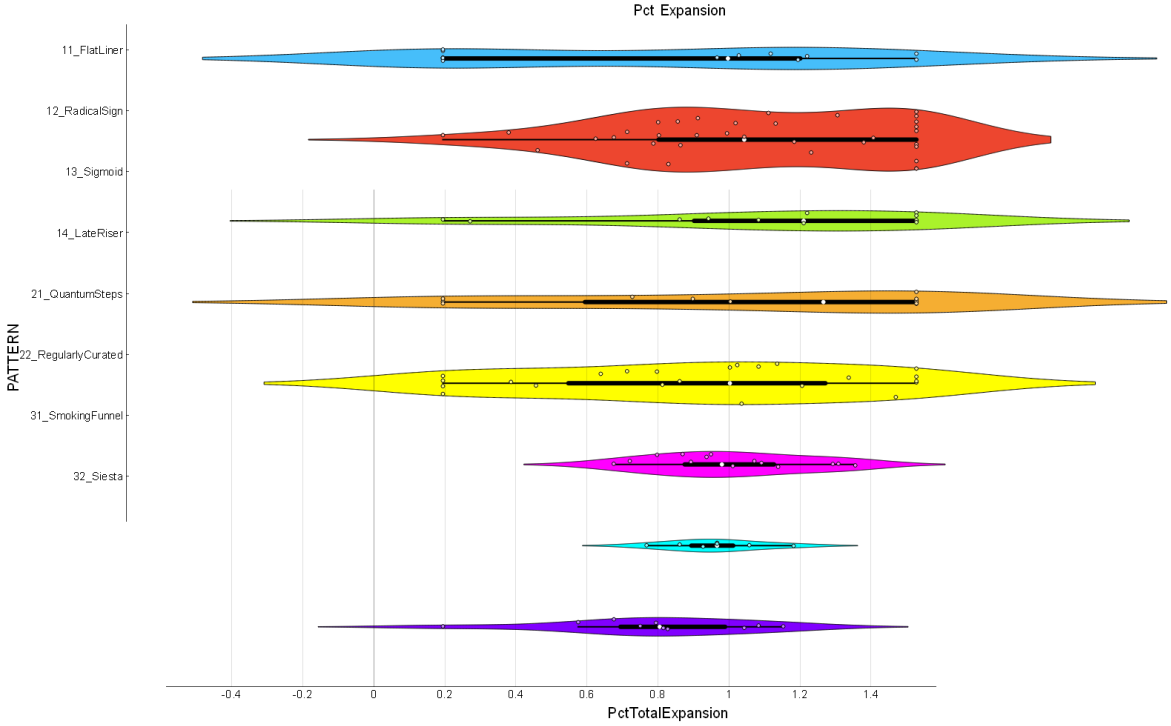


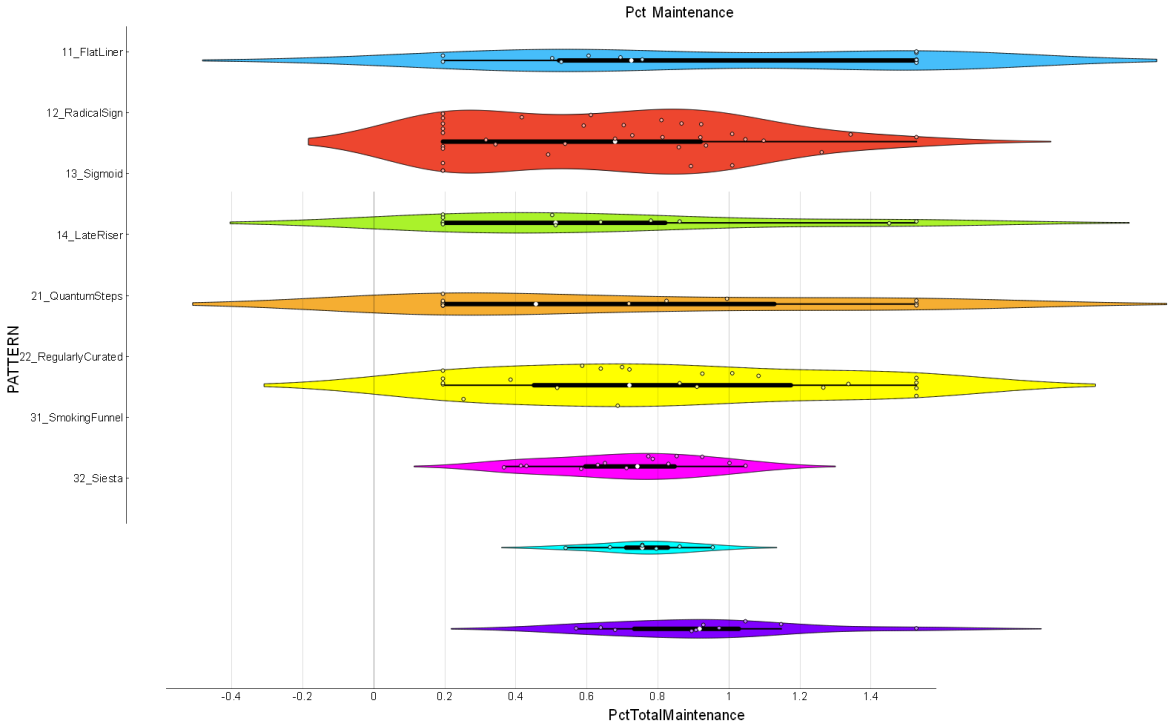
Total Attribute Ejection

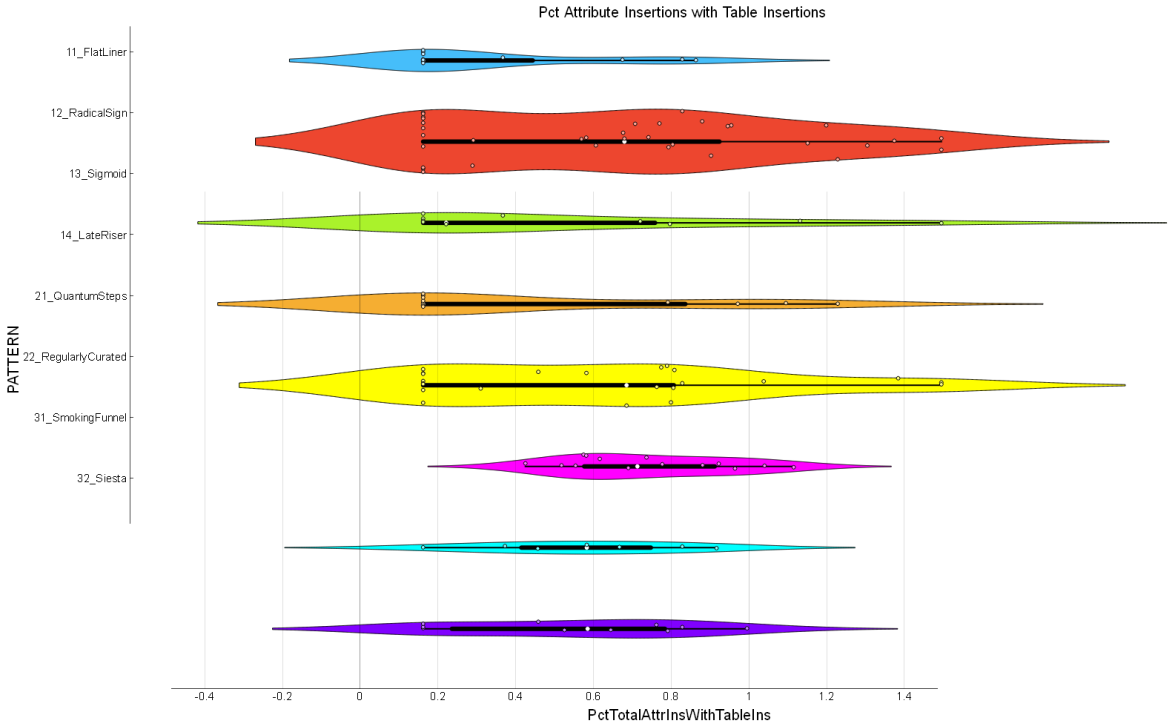


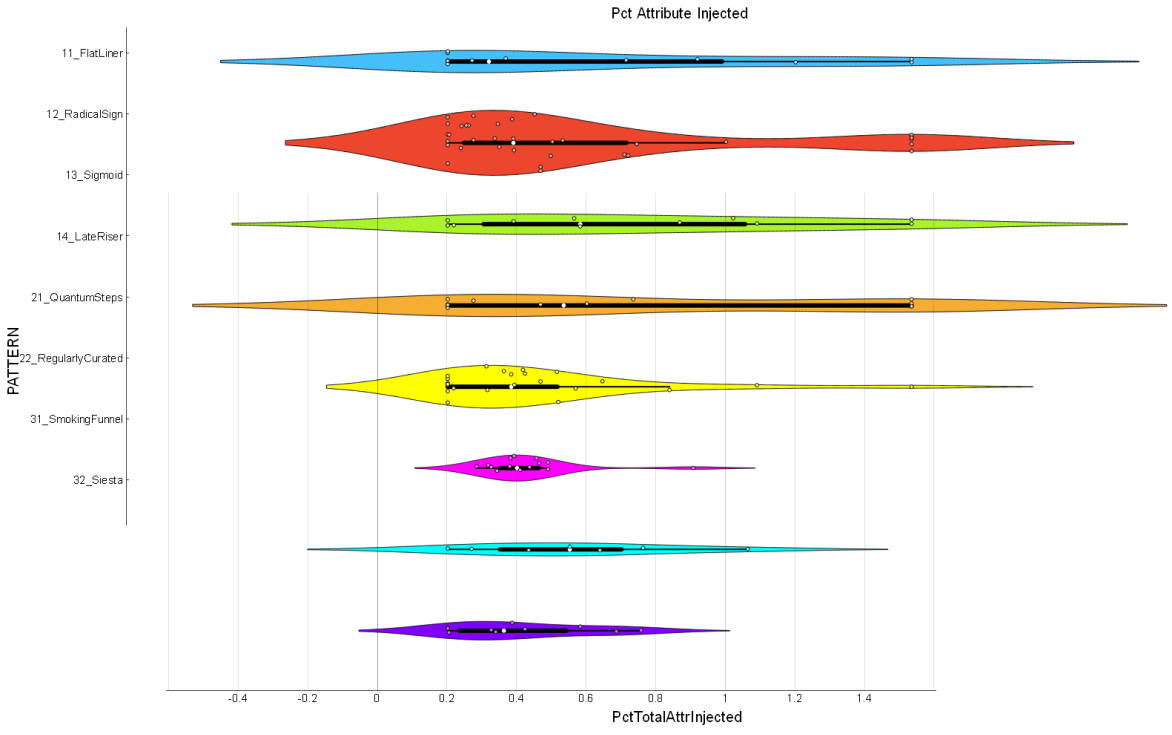
Total Attribute Change with PK Updates

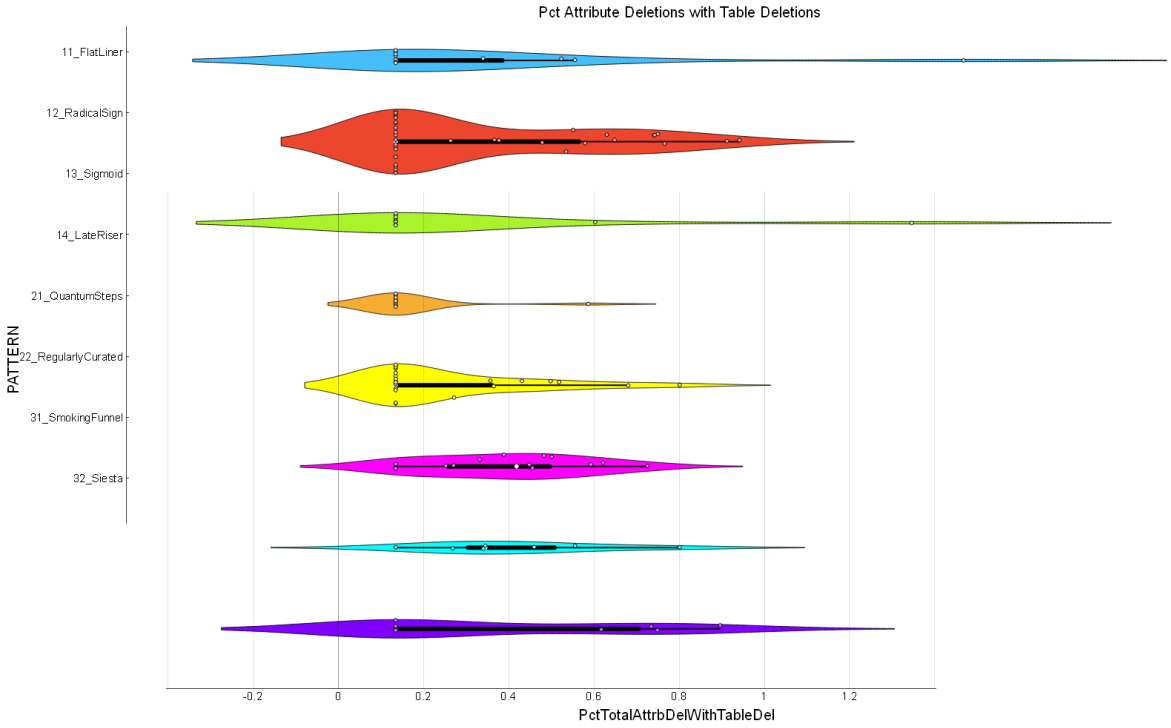
6 Violin Plots of Percentages for the different Categories of Change

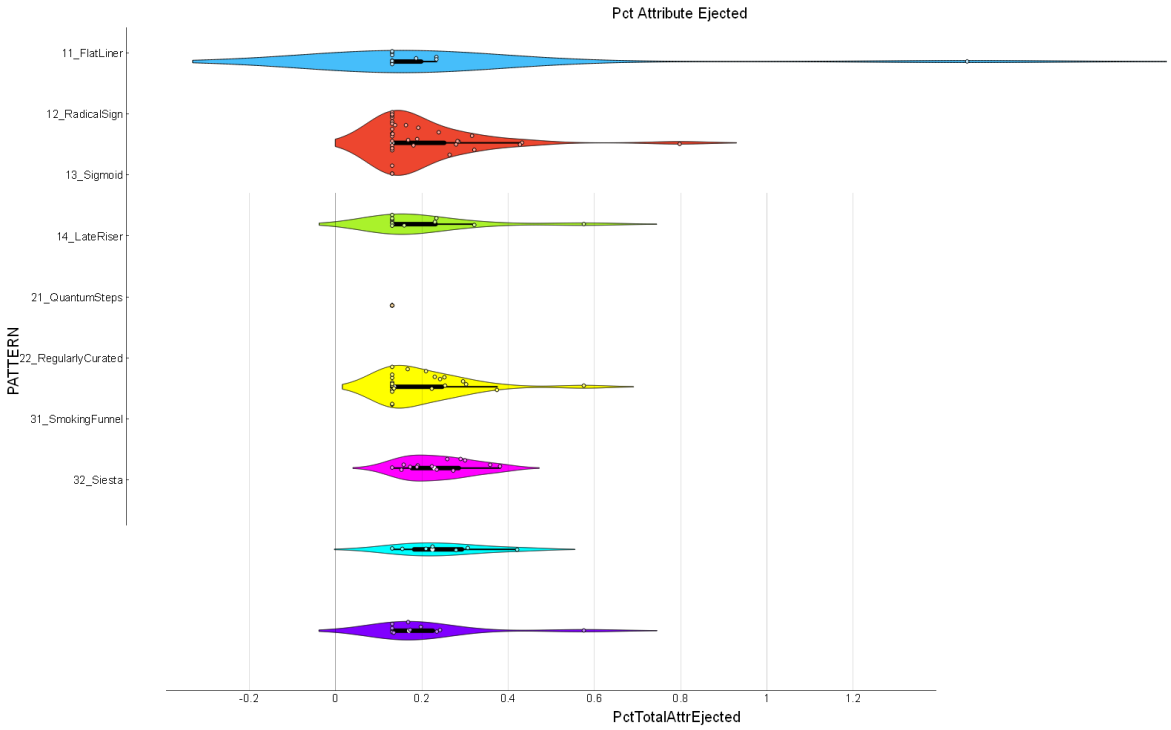


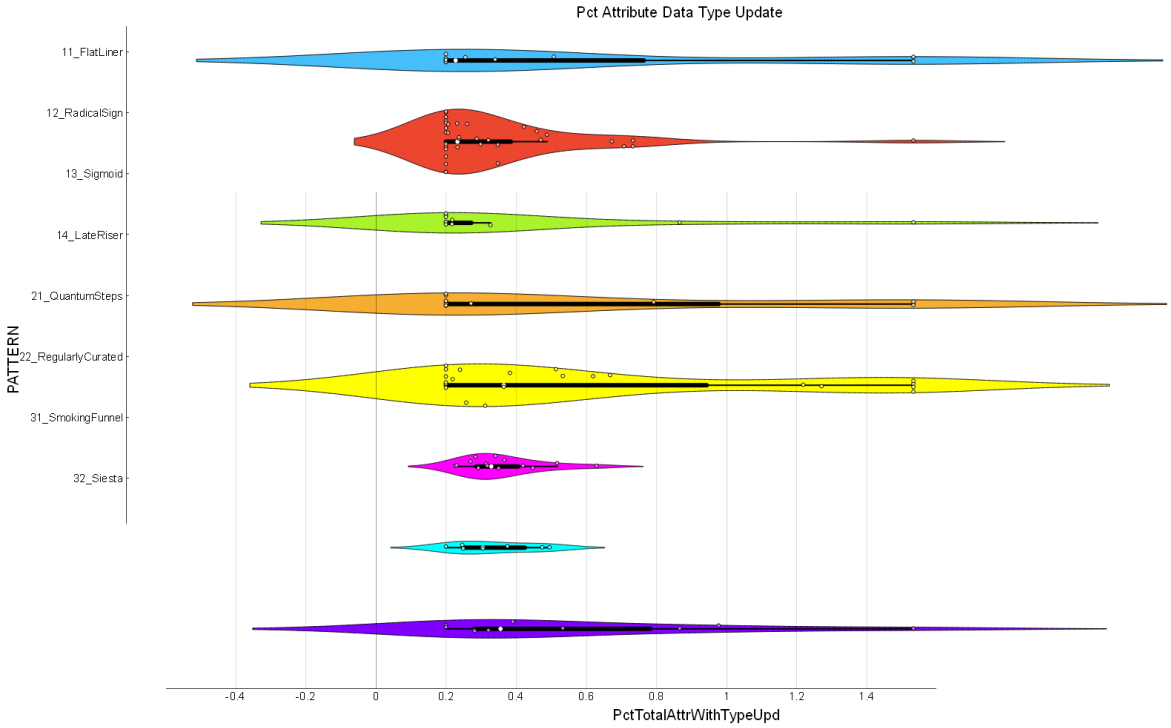


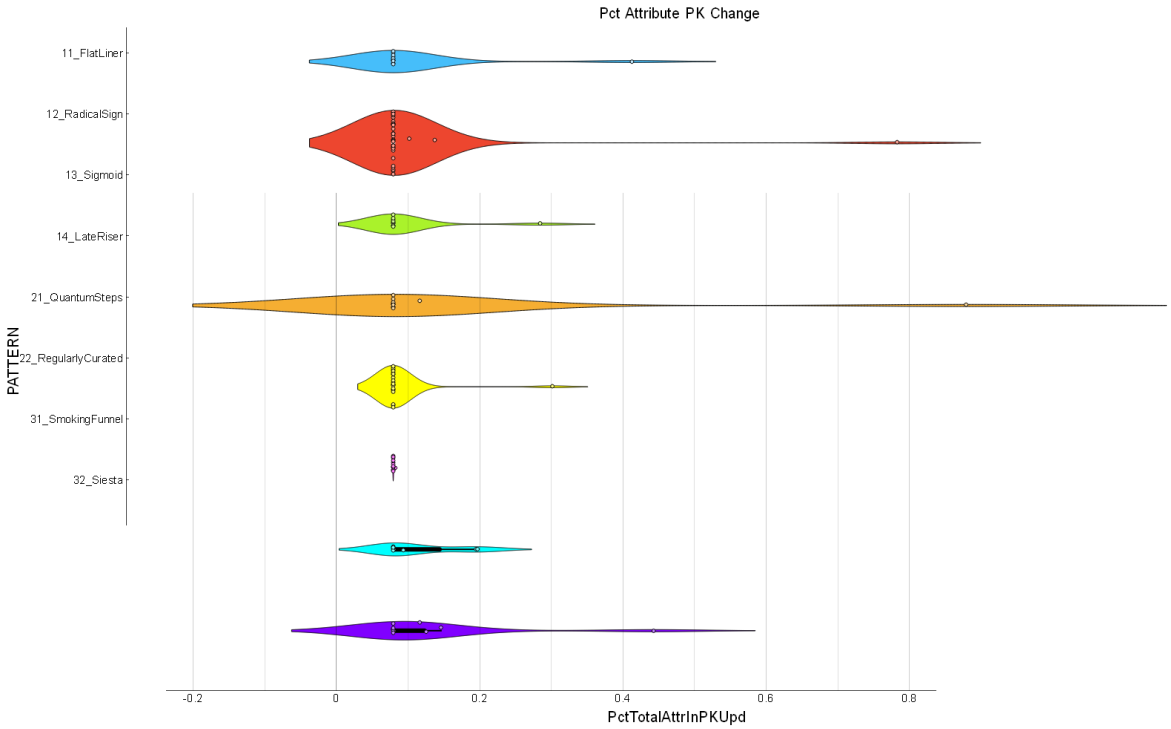

Pct Attribute Insertions with Table Insertions
11_FlatLiner
12_RadicalSign
13_Sigmoid
14_LateRiser
21_QuantumSteps
22_RegularlyCurated
31_SmokingFunnel
32_Siesta
PATTERN
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
PctTotalAttrInsWithTableIns


Pct Attribute Injected
11_FlatLiner
12_RadicalSign
13_Sigmoid
14_LateRiser
21_QuantumSteps
22_RegularlyCurated
31_SmokingFunnel
32_Siesta
PATTERN
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
PctTotalAttrInjected


Pct Attribute Deletions with Table Deletions
11_FlatLiner
12_RadicalSign
13_Sigmoid
14_LateRiser
21_QuantumSteps
22_RegularlyCurated
31_SmokingFunnel
32_Siesta
PATTERN
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
PctTotalAttrbDelWithTableDel


Pct Attribute Ejected
11_FlatLiner
12_RadicalSign
13_Sigmoid
14_LateRiser
21_QuantumSteps
22_RegularlyCurated
31_SmokingFunnel
32_Siesta
PATTERN
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
PctTotalAttrEjected


Pct Attribute Data Type Update
11_FlatLiner
12_RadicalSign
13_Sigmoid
14_LateRiser
21_QuantumSteps
22_RegularlyCurated
31_SmokingFunnel
32_Siesta
PATTERN
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
PctTotalAttrWithTypeUpd


Pct Attribute PK Change
11_FlatLiner
12_RadicalSign
13_Sigmoid
14_LateRiser
21_QuantumSteps
22_RegularlyCurated
31_SmokingFunnel
32_Siesta
PATTERN
-0.2
0
0.2
0.4
0.6
0.8
PctTotalAttrInPKUpd

7 Detailed Data

PATTERN	#Change Types	% Attr Ins w. Tbl Ins	% Attr Del w. Tbl Del	% Attr Inj.	% Attr Ej.	% Attr Type Upd	% Attr PK Upd	% Expansion	% Maintenance	Attr Ins w. Tbl Ins	Attr Del w. Tbl Del	Attr Inj.	Attr Ej.	Attr Type Upd	Attr PK Upd	Expansion	Maintenance
FlatLiner	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	1	0%	0%	0%	100%	0%	0%	0%	100%	0	0	0	1	0	0	0	1
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	2	0	0	2
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	3	0	0	3
	1	0%	100%	0%	0%	0%	0%	0%	100%	0	3	0	0	0	0	0	3
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	7	0	0	7
	4	53%	32%	5%	0%	11%	0%	58%	42%	10	6	1	0	2	0	11	8
	5	50%	29%	13%	4%	4%	0%	63%	38%	12	7	3	1	1	0	15	9
	4	15%	0%	54%	8%	23%	0%	69%	31%	2	0	7	1	3	0	9	4
	2	0%	0%	75%	0%	0%	25%	75%	25%	0	0	3	0	0	1	3	1
	4	38%	15%	38%	8%	0%	0%	77%	23%	5	2	5	1	0	0	10	3
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
12_RadicalSig	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	9	0	0	9
	4	0%	0%	14%	14%	19%	53%	14%	86%	0	0	10	10	14	38	10	62
	4	0%	30%	20%	10%	40%	0%	20%	80%	0	3	2	1	4	0	2	8
	5	10%	10%	23%	23%	35%	0%	32%	68%	3	3	7	7	11	0	10	21
	5	31%	58%	6%	3%	3%	0%	36%	64%	11	21	2	1	1	0	13	23
	3	0%	0%	39%	50%	11%	0%	39%	61%	0	0	7	9	2	0	7	11
	5	39%	61%	0%	0%	0%	0%	39%	61%	489	767	4	1	6	0	493	774
	5	33%	33%	11%	11%	11%	0%	44%	56%	3	3	1	1	1	0	4	5
	5	41%	45%	5%	5%	5%	0%	45%	55%	9	10	1	1	1	0	10	12
	6	31%	39%	14%	11%	3%	2%	46%	54%	169	207	76	61	15	9	245	292
	4	10%	0%	38%	14%	38%	0%	48%	52%	2	0	8	3	8	0	10	11

PATTERN	#Change Types	% Attr Ins w. Tbl Ins	% Attr Del w. Tbl Del	% Attr Inj.	% Attr Ej.	% Attr Type Upd	% Attr PK Upd	% Expansion	% Maintenance	Attr Ins w. Tbl Ins	Attr Del w. Tbl Del	Attr Inj.	Attr Ej.	Attr Type Upd	Attr PK Upd	Expansion	Maintenance
	5	46%	46%	4%	2%	2%	0%	50%	50%	57	57	5	3	3	0	62	63
	4	47%	47%	3%	0%	2%	0%	50%	50%	134	134	8	0	7	0	142	141
	6	43%	17%	10%	4%	20%	4%	54%	46%	30	12	7	3	14	3	37	32
	2	54%	46%	0%	0%	0%	0%	54%	46%	7	6	0	0	0	0	7	6
	2	0%	0%	60%	0%	40%	0%	60%	40%	0	0	3	0	2	0	3	2
	5	59%	37%	3%	1%	1%	0%	62%	38%	117	74	6	1	1	0	123	76
	5	39%	18%	25%	12%	7%	0%	64%	36%	47	22	30	14	8	0	77	44
	3	50%	31%	19%	0%	0%	0%	69%	31%	8	5	3	0	0	0	11	5
	4	59%	0%	11%	8%	22%	0%	70%	30%	22	0	4	3	8	0	26	11
	2	74%	26%	0%	0%	0%	0%	74%	26%	23	8	0	0	0	0	23	8
	3	56%	0%	22%	22%	0%	0%	78%	22%	15	0	6	6	0	0	21	6
	3	78%	0%	6%	0%	17%	0%	83%	17%	14	0	1	0	3	0	15	3
	4	48%	0%	41%	4%	7%	0%	89%	11%	13	0	11	1	2	0	24	3
	2	91%	0%	0%	0%	9%	0%	91%	9%	10	0	0	0	1	0	10	1
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	2	0	0	0	2	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	2	0	0	0	2	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	3	0	0	0	3	0
	2	80%	0%	20%	0%	0%	0%	100%	0%	4	0	1	0	0	0	5	0
	1	100%	0%	0%	0%	0%	0%	100%	0%	5	0	0	0	0	0	5	0
	1	100%	0%	0%	0%	0%	0%	100%	0%	9	0	0	0	0	0	9	0
	2	86%	0%	14%	0%	0%	0%	100%	0%	12	0	2	0	0	0	14	0
13_Sigmoid	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	2	0	0	2
	5	4%	91%	1%	2%	1%	0%	6%	94%	17	348	5	8	5	0	22	361
	2	0%	0%	50%	0%	50%	0%	50%	50%	0	0	1	0	1	0	1	1
	5	42%	35%	14%	7%	1%	0%	56%	44%	62	52	21	11	2	0	83	65
	2	0%	0%	67%	33%	0%	0%	67%	33%	0	0	6	3	0	0	6	3
	4	48%	0%	29%	14%	10%	0%	76%	24%	10	0	6	3	2	0	16	5
	4	15%	0%	62%	8%	0%	15%	77%	23%	2	0	8	1	0	2	10	3
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	4	0	0	0	4	0
	1	100%	0%	0%	0%	0%	0%	100%	0%	6	0	0	0	0	0	6	0

PATTERN	#Change Types	% Attr Ins w. Tbl Ins	% Attr Del w. Tbl Del	% Attr Inj.	% Attr Ej.	% Attr Type Upd	% Attr PK Upd	% Expansion	% Maintenance	Attr Ins w. Tbl Ins	Attr Del w. Tbl Del	Attr Inj.	Attr Ej.	Attr Type Upd	Attr PK Upd	Expansion	Maintenance
	2	73%	0%	27%	0%	0%	0%	100%	0%	8	0	3	0	0	0	11	0
14_LateRiser	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	0	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0	0	0	0	0	0
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	2	0	0	2
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	3	0	0	3
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	3	0	0	3
	2	0%	0%	40%	0%	0%	60%	40%	60%	0	0	2	0	0	3	2	3
	4	47%	0%	6%	0%	44%	3%	53%	47%	17	0	2	0	16	1	19	17
	3	61%	34%	0%	0%	5%	0%	61%	39%	68	38	0	0	6	0	68	44
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	1	0	0	0	1	0
	2	80%	0%	20%	0%	0%	0%	100%	0%	4	0	1	0	0	0	5	0
	2	70%	0%	30%	0%	0%	0%	100%	0%	7	0	3	0	0	0	10	0
21_Quantum	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	2	0	0	2
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	2	0	0	2
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	3	0	0	3
	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	4	0	0	4
	3	0%	0%	14%	9%	76%	0%	14%	86%	0	0	25	16	133	0	25	149
	3	11%	0%	9%	0%	80%	0%	20%	80%	13	0	10	0	94	0	23	94
	5	0%	17%	33%	8%	25%	17%	33%	67%	0	2	4	1	3	2	4	8
	5	22%	22%	17%	7%	31%	0%	39%	61%	12	12	9	4	17	0	21	33
	5	32%	29%	14%	12%	14%	0%	45%	55%	23	21	10	9	10	0	33	40
	5	45%	41%	1%	0%	12%	0%	46%	54%	142	129	4	1	39	0	146	169
	2	50%	50%	0%	0%	0%	0%	50%	50%	2	2	0	0	0	0	2	2
	5	48%	27%	12%	9%	3%	0%	61%	39%	16	9	4	3	1	0	20	13
	4	46%	0%	16%	3%	35%	0%	62%	38%	17	0	6	1	13	0	23	14
	5	39%	10%	24%	18%	8%	0%	63%	37%	84	22	51	39	18	0	135	79
	2	0%	0%	67%	33%	0%	0%	67%	33%	0	0	2	1	0	0	2	1
	4	47%	0%	24%	6%	24%	0%	71%	29%	8	0	4	1	4	0	12	5
	4	48%	17%	28%	7%	0%	0%	76%	24%	14	5	8	2	0	0	22	7
	4	66%	0%	20%	13%	1%	0%	86%	14%	46	0	14	9	1	0	60	10
	3	48%	0%	48%	0%	4%	0%	96%	4%	11	0	11	0	1	0	22	1
	1	0%	0%	100%	0%	0%	0%	100%	0%	0	0	2	0	0	0	2	0
	1	100%	0%	0%	0%	0%	0%	100%	0%	3	0	0	0	0	0	3	0
	1	100%	0%	0%	0%	0%	0%	100%	0%	6	0	0	0	0	0	6	0
	2	92%	0%	8%	0%	0%	0%	100%	0%	11	0	1	0	0	0	12	0
22_Regularly	5	27%	44%	9%	3%	16%	0%	36%	64%	94	156	33	11	58	0	127	225
	5	20%	37%	20%	19%	5%	0%	39%	61%	60	111	60	57	16	0	120	184
	5	31%	19%	14%	12%	24%	0%	45%	55%	13	8	6	5	10	0	19	23
	5	31%	26%	19%	13%	11%	0%	51%	49%	457	379	278	184	154	0	735	717

PATTERN	#Change Types	% Attr Ins w. Tbl Ins	% Attr Del w. Tbl Del	% Attr Inj.	% Attr Ej.	% Attr Type Upd	% Attr PK Upd	% Expansion	% Maintenance	Attr Ins w. Tbl Ins	Attr Del w. Tbl Del	Attr Inj.	Attr Ej.	Attr Type Upd	Attr PK Upd	Expansion	Maintenance
	6	46%	34%	6%	4%	9%	0%	52%	48%	1774	1321	240	171	331	8	2014	1831
	5	34%	15%	22%	17%	13%	0%	56%	44%	30	13	19	15	11	0	49	39
	5	43%	27%	14%	10%	6%	0%	57%	43%	306	195	96	68	45	0	402	308
	5	40%	24%	22%	8%	7%	0%	61%	39%	97	59	53	19	17	0	150	95
	4	57%	0%	9%	2%	32%	0%	66%	34%	85	0	13	3	48	0	98	51
	5	54%	24%	13%	7%	2%	0%	67%	33%	117	51	29	15	5	0	146	71
	4	60%	0%	11%	11%	19%	0%	71%	29%	68	0	12	12	21	0	80	33
	4	29%	9%	53%	0%	9%	0%	82%	18%	10	3	18	0	3	0	28	6
	5	66%	10%	18%	4%	2%	0%	84%	16%	168	26	45	11	5	0	213	42
	4	72%	0%	16%	2%	11%	0%	87%	13%	266	0	58	6	42	0	324	48
31_SmokingF	6	38%	24%	5%	2%	22%	9%	43%	57%	236	152	32	11	138	54	268	355
	2	50%	50%	0%	0%	0%	0%	50%	50%	95	95	0	0	0	0	95	95
	5	22%	15%	33%	22%	8%	0%	55%	45%	56	39	83	55	20	0	139	114
	5	16%	16%	42%	13%	13%	0%	58%	42%	6	6	16	5	5	0	22	16
	5	32%	32%	26%	7%	4%	0%	58%	42%	18	18	15	4	2	0	33	24
	4	0%	0%	65%	6%	21%	9%	65%	35%	0	0	22	2	7	3	22	12
	6	57%	10%	17%	11%	4%	1%	74%	26%	107	19	33	21	7	2	140	49
32_Siesta	1	0%	0%	0%	0%	100%	0%	0%	100%	0	0	0	0	2	0	0	2
	3	0%	57%	29%	0%	14%	0%	29%	71%	0	8	4	0	2	0	4	10
	5	22%	0%	14%	3%	58%	3%	36%	64%	8	0	5	1	21	1	13	23
	3	0%	0%	42%	8%	50%	0%	42%	58%	0	0	10	2	12	0	10	14
	4	45%	45%	0%	5%	0%	5%	45%	55%	9	9	0	1	0	1	9	11
	6	36%	36%	10%	8%	6%	3%	47%	53%	42	42	12	9	7	4	54	62
	5	47%	46%	0%	0%	6%	0%	47%	53%	169	165	1	1	22	0	170	188
	4	27%	0%	36%	0%	9%	27%	64%	36%	3	0	4	0	1	3	7	4
	3	50%	0%	17%	33%	0%	0%	67%	33%	3	0	1	2	0	0	4	2
	4	63%	0%	9%	3%	25%	0%	72%	28%	20	0	3	1	8	0	23	9