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## Analysis of TDS data with a stochastic approach

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## INTRODUCTION

- ✓ Statistical analysis of Temporal Dominance of Sensations (TDS) data only relies on TDS curves and on dominance duration analysis
- ✓ This classical analysis provides a mean panel overview and no information about individual perception and differences of perception

## OBJECTIVES

- ✓ To fit a Semi-Markov Chains (SMC) model on TDS data by product
- ✓ To reveal the existence of time periods requiring different SMC models along perception of a single intake
- ✓ To segment consumers according to their temporal perception thanks to a mixture model of SMCs

## METHODS DEVELOPED & IMPLEMENTED IN R AND C++

### SEMI-MARKOV CHAINS

- Modeling attribute choices with a Markov chain by estimating probabilities to choose each attribute given the current dominant attribute
- Estimating of dominance durations with negative binomial laws

### SPLITTING SEQUENCES INTO TIME PERIODS

- Probabilities to move from one attribute to another can depend on time. Sequences are split into time periods modeled with one SMC by time period.
- Number of periods is chosen using a statistical test
  - Locations of frontiers between periods are determined automatically by a maximization algorithm of proper likelihood

Lecuelle, G., Visalli, M., Cardot, H., & Schlich, P. (2017). Modeling Temporal Dominance of Sensations with semi-Markov chains. Food Quality and Preference.

### TDS GRAPH

Markov graph is a directed graph having vertices representing attributes and arrows representing transitions, labeled by the probabilities to go from one sensory attribute to another one. TDS graph is a simplified Markov graph displaying:

- attributes quoted by at least one half of the panelists for the current product;
- transition probabilities greater than  $\frac{1}{n+2}$ ,  $n$  being the number of selected attributes;
- arrows colored to represent the time period while transitions occurred;
- width of arrows proportional to the value of the corresponding transition probability;
- size of attribute circles proportional to the mean dominance duration of the attribute.

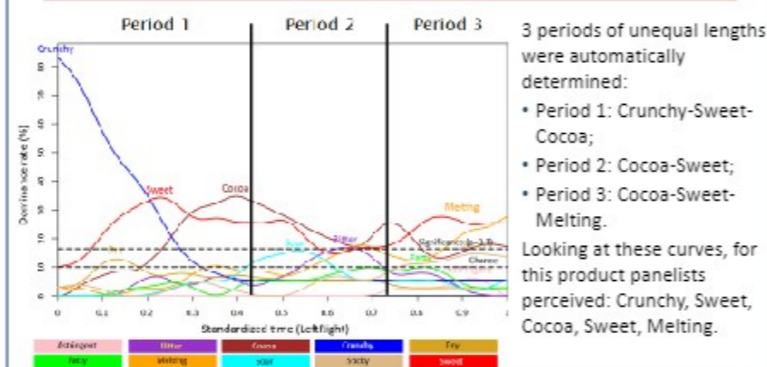
### MODEL BASED SEGMENTATION

We assume there are some sub-populations in the panel having differences of temporal perception of the product.

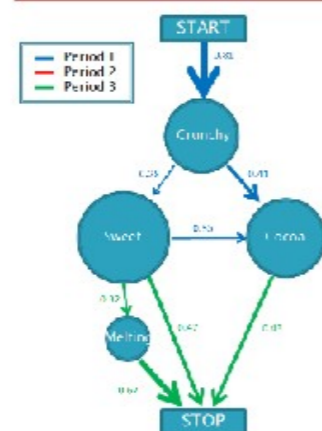
The segmentation of the panel by perception is done using a mixture of semi-Markov chains. Parameters of the mixture are estimated with the EM algorithm. The segmentation is performed by estimating for each panelist the posterior probabilities to belong to each segment and then affects panelists to the segment maximizing this probability.

## APPLICATION TO A 70% COCOA CHOCOLATE EVALUATED BY 36 CONSUMERS

### 1- TIME PERIODS



### 2- TDS GRAPH

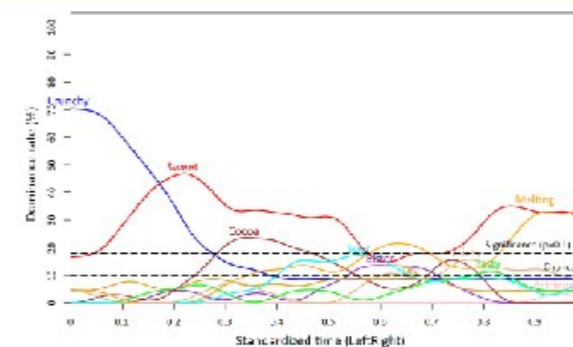


- The probability for a panelist to select Crunchy as the first attribute is equal to 0.81. If Crunchy is selected as dominant during the first time period then there is a probability of 0.41 to select Cocoa and a probability of 0.28 to select Sweet.
- The 4 sequences more likely to be observed are evidenced in this TDS-graph:
  - 1) Crunchy-Cocoa
  - 2) Crunchy-Sweet
  - 3) Crunchy-Sweet-Cocoa
  - 4) Crunchy-Sweet-Melting
- No significant transition during the second period.

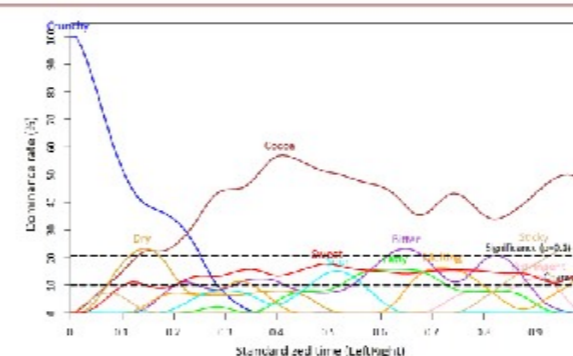
### 3- SEGMENTATION

The algorithm found two consumer segments. In the first group, panelists mainly perceived Crunchy, then Sweet and finally Melting, whereas in the second group panelists mainly perceived Crunchy then Cocoa.

#### Group 1: n=23



#### Group 2: n=13



## CONCLUSIONS

- ✓ Modeling of TDS data with semi-Markov chains offers a better insight into temporal perception and provides complementary information to classic TDS analyses
- ✓ The automatic split of sequences into time periods gives information about the different phases of temporal perception of the product
- ✓ The TDS graph shows the most likely individual sequences of attribute perceptions and the strengths of transition from one attribute to another
- ✓ Differences of temporal product perception in the panel are uncovered and statistically validated thanks to the segmentation algorithm