Bridging consumer and technical sensory perspective on characterization of skin care products

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Abstract

Background:

It is important to gain the understanding of consumer perspectives using consumer-centric methods to translate the subtle differences in sensory language that is understood by all stakeholders. This study seeks to address the gap of consumer language (Semantics) and technical sensory language (Syntax) in the characterisation of personal care products, thus accelerating formulation development with targeted and desired sensorial experience through a predictive skin care ingredient selection.

Methods:

Twelve oil-in-water emulsifiers were selected and formulated in simple chassis as emulsifier is the key ingredient driving the initial sensory feel of skin care products.

A methodology, MATCH-SENSE-MATRIX, was developed to bridge consumer and technical sensory language (MATCH), to understand the sensory space of oil-in-water emulsifiers using the consumer language (SENSE), and to understand the relationship between liquidity of samples and consumer attributes (MATRIX). The study was conducted with about 100 consumers each from Singapore and France.

Results:

An agreement of RV>70% between the consumer and technical sensory terms, was obtained for both Singaporeans and French consumer groups. The mapping of semantics with Syntax, using

Multiple Factor Analysis (MFA) was translated into a language wheel which is categorised in 4 quadrants for both consumer groups. Matrix diagrams were created to visualise perceived intensities of 12 emulsifiers across consumer attributes.

Conclusion:
This SenStories™ methodology and tool enables predictive ingredients selection based on the consumer desired sensory for skin care formulations. This improves collaboration between marketing and formulators in optimizing product development time.

Keywords: consumer language; technical sensory; emulsifiers; predictive tool

Introduction.
This study seeks to address the gap of consumer language (Semantics) and technical sensory language (Syntax) in the characterisation of personal care products, in particular the oil-in-water emulsifiers, thus expediting formulation development through a predictive skin care ingredient selection. It is important to gain the understanding of consumer perspectives using consumer-centric methods, albeit characterisation of the sensory properties of products remains a cornerstone activity for sensory professionals. Our objectives for this paper were: (1) Connecting and merging technical sensory with consumer perception, (2) Understand cross-cultural consumer perception, (3) Develop tool that allows predictive ingredient selection based on consumers' desired sensory profile.

In this study, we used both trained and consumer panel to evaluate the commercial formulations and Croda prototypes. A methodology, MATCH-SENSE-MATRIX, was developed to bridge consumer and technical sensory language. The results from the consumer evaluation enable us to match the consumer language with technical sensory (MATCH), to understand the sensory space of oil-in-water emulsifiers using the consumer language (SENSE), and to understand the relationship between liquidity of samples and consumer language (MATRIX).

Materials and Methods.

Formulation design

Twelve oil-in-water emulsifiers which represent a specific range of Croda portfolio based on popularity amongst customers have been selected to develop oil-in-water emulsion.

This selection process in Croda emulsifier portfolio was made by analysing previous sensory evaluation on complex formulations using a trained sensory panel. This is to ensure that we covered a wide spectrum of sensories which were differentiating among these formulations, and among different chemistries of emulsifiers (***Figure 1).***

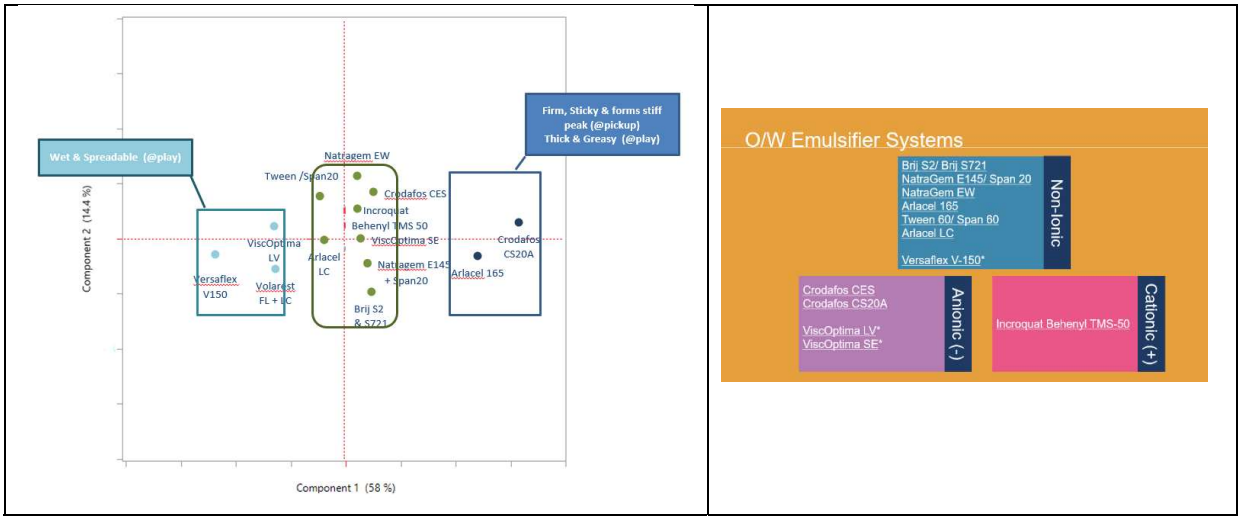

Figure 1 **:** *Selection of 12 water in oil emulsifiers and their chemistry*

A formulation design has been developed to allow the comparison of all the formulations and then to analyse the impact of the emulsifiers on sensories. Two levels of emulsifier were used depending on their capability to emulsify or emulsify with gelling properties. A simple formulation named “chassis” and its composition is described in ***Table I***.

Table I : *Chassis used in the 12 simple formulations*

INCI, (Supplier)	%
Water	Qsp 100
Glycerin, (Croda)	1.5
Xanthan gum, (CP Kelco)	0.15
Emulsifier system, (Croda)	5 % (emulsifier) or 1% (gelling emulsifier)
Stearyl alcohol (Croda)	1.5
Caprylic/Capric Triglyceride, (Croda)	10
Phenoxyethanol & Ethylhexylglycerin, (Ashland)	0.8

Some of the selected emulsifiers were not stable with this common chassis, thus a formulation based on the stability has been developed and then validated by sensory analysis via triangle test. Two emulsifiers have been stabilised with an additional 0.5% stearyl alcohol and two others with xanthan gum (0.4% - 0.75%).

It was important to check that the minor change in the composition did not impact the sensory of the formulation otherwise it could have impacted the result of the comparison.

Similarly, some processing steps were investigated to establish a control protocol in formulation.

Sample preparation

The water phase was prepared by adding glycerin to distilled water and then pouring xanthan gum into it under stirring with a propeller (Turbotest, VMI, France). The oil phase was prepared by adding the selected emulsifier system to the GTCC and stearyl alcohol. The two phases were heated to 75°C and once both at the same temperature and homogeneous, the emulsion was prepared by having the oil phase added to water phase while stirring with a propeller stirrer under fast stirring (max vortex, without air incorporation) for 5 minutes. The emulsion was then cooled down under medium stirring before the addition of the preservative at 40°C. Low stirring was then used until the room temperature was reached.

Sensory Evaluation by trained panel

Croda adapts a descriptive analysis methodology which is a hybrid of Quantitative Descriptive Analysis (QDA) and Spectrum descriptive methods. It is called Croda Descriptive Analysis (CDA). The CDA methodology consists of 3 stages, namely @PickUp, @Play, and @Post Application. The @PickUp and @Play stage are also known as initial feel stage, while @Post Application is the afterfeel. @PickUp is the stage in which the formulation is 'picked up' from the dispenser, usually by the finger. @Play is the stage in which the formulation is applied and rubbed into the skin until absorption, while @Post Application (which is both immediate and after 5 minutes) is the stage after which the formulation has been applied and fully rubbed into the skin. A total of 21 predetermined attributes were measured against a pre-learnt absolute intensity scale from 0 to 100. These technical sensory descriptors are collectively known as Syntax in this study.

The trained panellists evaluated 2 sets of 12 samples. The first set comprised 12 market samples while the second set comprised 12 simple formulations with oil-in-water emulsifying systems. 0.05 g of each sample was used to evaluate attributes for @Play and @Post Application stages. For @PickUp stage, 0.10 g was used. Samples were presented in a sequential manner following the Latin Square experimental design. The evaluation was repeated twice.

Sensory Evaluation by consumer panel in Singapore and France

The consumer panel evaluation came in 3 phases in which Phase 1, 2 and 3 featured a survey, a projective technique known as word association [1], and an intensity rating method called Rate-all-that-apply (RATA).

Phase 1

In this phase, this is where a reference list of sensory descriptors from consumers, also known as Semantics, was collated. As there was pre-defined attribute list, a reference list of Semantics was developed. Consumers were asked to submit vocabulary that they would use to describe leave-on skin care products to form this list.

There were 120 Singaporean consumers being screened and recruited in which 80% were females. For France, there were 148 consumers being screened and recruited in which 85% were females. The age group ranged from 18 to 45 for both populations. They answered 8 questions of which one of the questions required them to list out 5 sensory attributes associated with the texture of skin care products. These attributes were recorded, and their frequencies of occurrence were analysed so that a list of attributes can be generated for Phase 2.

Phase 2

In Phase 2, the reference list for each consumer demographics was validated. Consumers were given market samples to evaluate and were asked to select vocabulary from the reference list that they would associate with the formulations. They were not limited to this list but may also use their own vocabulary to describe the formulation. A frequency count was then carried out and the list refined, removing vocabulary that was deemed irrelevant.

About 103 consumers from each consumer region participated in Phase 2. There were 85% were females, and their age group ranging from 18 to 45. Samples were presented in a balanced incomplete block and randomised order. Each panelist assessed 6 samples randomly and monadic sequentially. 0.05 g of each sample was used to evaluate attributes for @Play and @Post Application stages. @PickUp stage was not evaluated.

Consumers were required to list down three words for each stage by taking reference from a list of textural terms generated in Phase 1. They could also use their own descriptors. The results were analysed by frequency count and a list of attributes was consolidated for Phase 3.

Phase 3

Consumers from Phase 2 continued into Phase 3. In this phase, a method known as Rate-All-That-Apply (RATA) was used. They were required to select the appropriate sensory attributes for both @Play and @Post Application stage, and then rated the samples based on the selected attributes using a scale of 1 to 10.

The 12 market samples and 12 simple formulations were presented separately in a balanced incomplete block and randomised order. Each panelist assessed 4 samples randomly and monadic

sequentially within the market samples and simple formulations. Each sample were assessed 30 to 35 times. Liquidity assessment was performed on a scale from 1 to 10 (where 1 being very fluid and 10 being very viscous). This is to understand consumer perception in liquidity vs. consumer sensory terms (Semantics). Attribute (scale from 1 to 10 where 1 being low and 10 being high intensity) and overall liking assessment (scale from 1 being dislike extremely to 9 being like extremely) were performed on simple formulations and market samples. The results from the market samples enable us to match the consumer Semantics with Syntax. This matching process was only performed on market samples as the sensory attributes generated would be more extensive due to the wider range of textural variation exhibited by the market samples.

Statistical analysis:

Making the connection using Match-Sense-Matrix (MSM).

The results from RATA enable us to match the consumer language with technical sensory (MATCH), to understand the sensory space of 12 simple formulations using the consumer language (SENSE) and to understand the relationship between liquidity of samples and consumer language (MATRIX). Sensory space refers to the placement of the samples based on 2 dimensions, say dimension 1 and dimension 2. Each of this dimension represent certain attributes.

Different statistical approach was used to analyse the outcome of the RATA method. To match the consumer language from RATA with the technical sensory results by trained panel on the evaluation of market samples, multiple factor analysis (MFA) was performed. Multiple factor analysis (MFA) is an extension of principal component analysis (PCA) tailored to handle multiple data tables that measure sets of variables collected on the same observations [2]. MFA was used when we map both consumer and technical sensory data together and determine the level of agreement between the two groups. RV coefficient was calculated to determine consensual agreement between consumer and technical sensory data.

To understand the sensory space of 12 simple formulations using consumer language, Principal Component Analysis (PCA) was used. PCA is a dimensionality-reduction method that is used to reduce the dimensionality of large data sets into small ones which still contains most of the information in the large set [3]. To understand the relationship between liquidity and consumer

language, Pearson's Correlation was performed. In addition, Hierarchical cluster analysis was used to group the formulations based on their similarity.

To identify significant differences between the formulations, the statistical paired comparison test for each attribute was performed at the p = 0.05 level. All data analysis was carried out using the statistical package JMP ver. 16.

Results.

Based on a previous study by Wiechers et al. [4], it has shown that emulsifiers have a more pronounced influence during the initial phase of skin sensory evaluation than emollients, hence we will present the results from @Play stage only (also known as initial feel) in subsequent sections.

Generation of attributes by consumers

Using frequency count and word cloud data analysis, 17 words were generated by the Singapore consumers while the French generated 21 words at @Play stage (***Figure 2***).

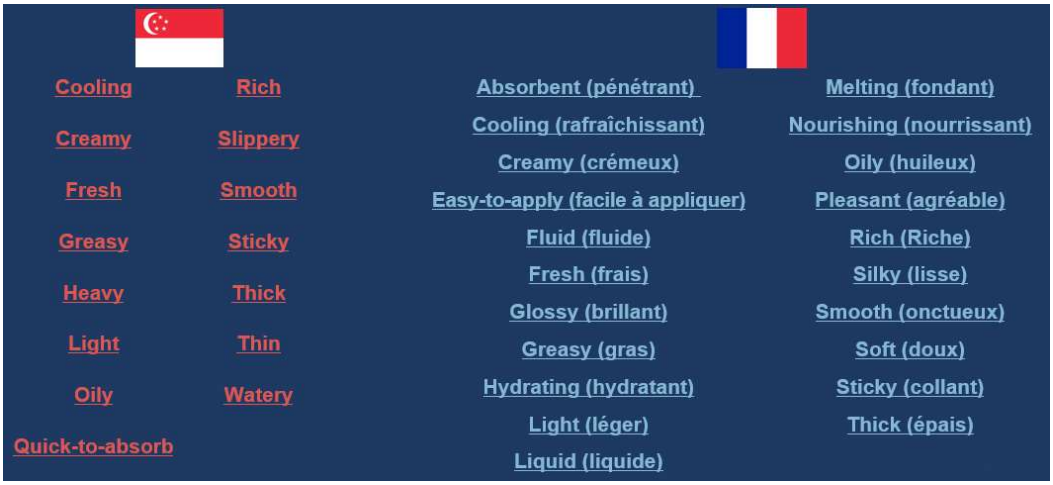

Figure 2**:** *Sensory attributes generated by consumers at @Play stage for Singaporean and French consumers*

Match

While the primary goal of MFA is to find groupings of products that are similar, it is also to determine if there is a good match between consumer language and technical sensory attributes (Semantics vs. Syntax) at both stages of @Play and @Post Application. It is found that there is

a good agreement between Singaporean consumer and trained panel based on the RV at 70% at @Play stage. Similarly, there is a good agreement between French consumer and trained panel based on the RV at 75%.

The mapping of Semantics with Syntax using MFA was translated into a language wheel with categorisation into 4 quadrants. The language wheel in ***Figure 3*** is a simple illustration to indicate the association between Syntax- technical sensory attributes (which are indicated on the outer circle), and Semantics - consumer language (inner circle). When attributes like oily and greasy are found in 2 adjacent quadrants, as shown in both language wheels, they were written on the line shared between the quadrants.

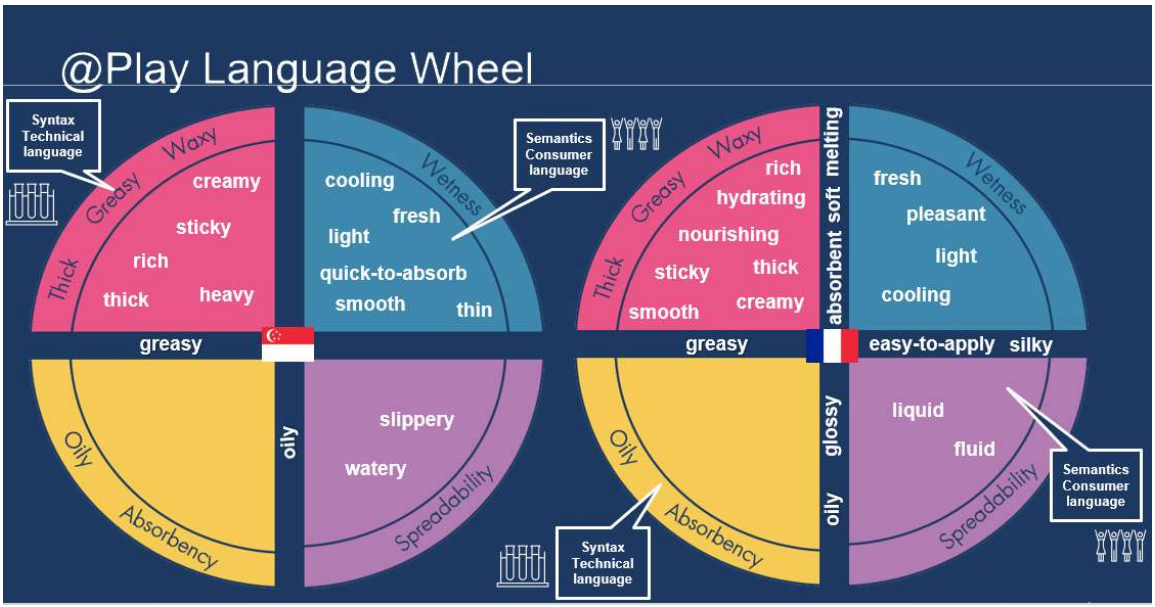

Figure 3**:** *Language wheel showing the association between consumer language (Semantics) and technical sensory (Syntax) attributes @Play stage for Singaporean and French consumers*

Sense

In the terminology - Sense, the sensory space and drivers of liking of the 12 simple formulations were determined and appreciated. ***Figure 4*** showed the PCA plots for @Play for Singaporean and French consumers.

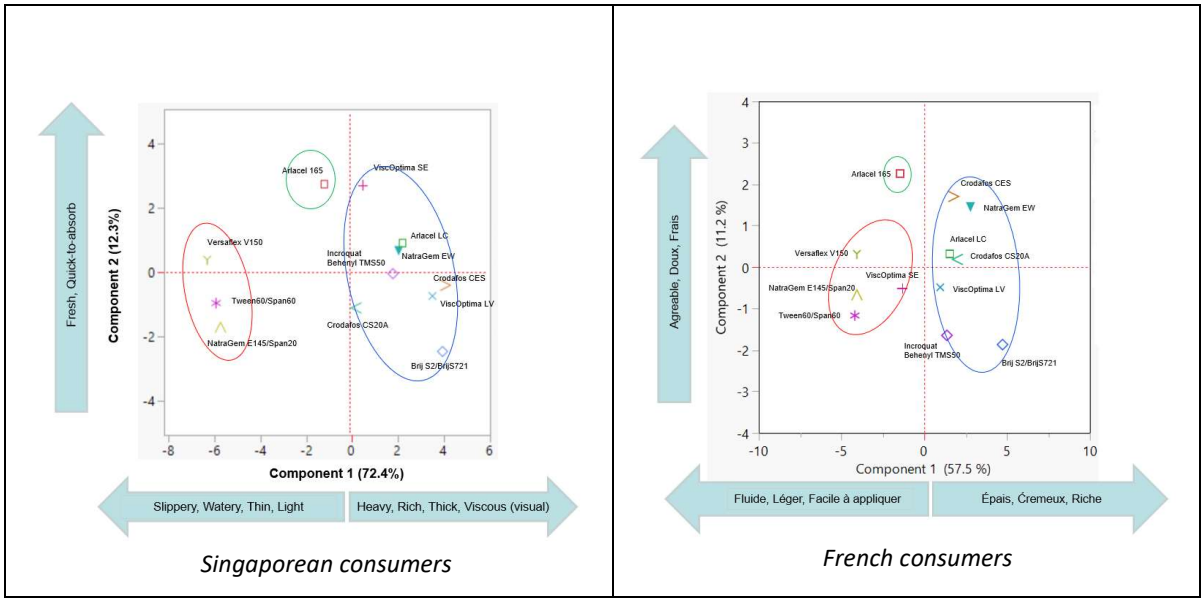

Figure 4 **:** *PCA plot for 12 simple formulations at @Play stage for Singaporean and French consumers*

PCA was performed on the 17 sensory attributes for the 12 simple formulations at @Play stage for Singaporean consumers. Based on the PCA plot in ***Figure 4***, the first two components explained 84.7% of the variance of the experimental data where first principal component (PC1) accounted for 72.4% of the variance while the second principal component (PC2) accounted for 12.3%. The PC1 was related to attributes related to heavy, rich, thick and viscous (visual liquidity) as the positive contribution; slippery, thin, light and watery as negative contribution of PC1. The PC2 was related to properties that were fresh and quick-to-absorb. The 12 simple formulations could be sorted into three groups with different sensory characteristics. The blue cluster showed heaviness, thickness and rich properties, while green cluster exhibited samples with more fresh property. The red cluster showed watery, light and slippery properties.

Similarly, PCA was performed on the 21 sensory attributes for the 12 simple formulations at @Play stage for the French consumers. Based on the PCA plot in ***Figure 4***, the first two components explained 68.7% of the variance of the experimental data where PC1 accounted for 57.5% of the variance while the PC2 accounted for 11.2%. The PC1 was related to attributes related to “épais, crémeux and riche” as the positive contribution; “fluide, léger, facile à appliquer” as negative contribution of PC1. The PC2 was related to properties that were “agréable, doux and frais”. The 12 simple fomulations could be sorted into three groups with

different sensory characteristics. The red cluster showed more fluid and light properties that was easy to apply, while the green cluster exhibited samples with more fresh property though lighter texture. The blue cluster was showing heavier and richer properties compared to the other 2 clusters.

Preference Drivers

The top 5 preference drivers on the 12 simple formulations for the Singapore consumers were slippery, smooth, quick-to-absorb, thin and fresh ***(Figure 5)***. For the French consumers, the top 5 preference drivers on the 12 samples were pleasant, fresh, spreadable, soft and nourishing. Emulsifier systems that were regarded highly in both regions NatraGem EW, Versaflex V150 and Arlacel 165.

Semantic (Singapore)	1st Emulsifier system	2nd Emulsifier system
1. Slippery	NatraGem E145/Span 20	Versaflex V150
2. Smooth	ViscOptima SE	Crodafos CS20A
3. Quick-to-absorb	NatraGem EW	Arlacel 165
4. Thin	Versaflex V150	NatraGem E145/Span 20
5. Fresh	Versaflex V150	Arlacel 165

Semantic (France)	1st Emulsifier system	2nd Emulsifier system
1. Pleasant (agréable)	Arlacel 165	NatraGem EW
2. Fresh (frais)	Arlacel 165	Versaflex V150
3. Spreadable (facile à appliquer)	Tween 60/Span 60	Versaflex V150
4. Soft (doux)	NatraGem EW	Arlacel 165
5. Nourishing (nourrissant)	NatraGem EW	ViscOptima LV

Figure 5 : *The top preference drivers for both regions were shown along with the top 2 emulsifier systems that evoked these consumer sensory reactions.*

On another note, when evaluating the 12 simple formulations, the frequency of significant differences in the attributes were much larger during the @Play stage as compared to @Post Application stage (137 vs. 87 for Singaporean consumers; 258 vs. 141 for French consumers). This again confirms that emulsifiers determine the skin feel during the play stage of skin sensory evaluation [4].

Matrix

In Matrix, the relationship between liquidity (visual-sensory) and consumer language is illustrated using matrix diagrams. The liquidity of the samples were evaluated by tilting the container. The panelists rated how the samples flow based on a rating from 1 to 10 where 1 is very liquid and 10 is less liquid.

The purpose of the matrix diagram was to visualize the trend of consumer attributes across visual liquidity. The following plot represents "slippery" at @Play stage vs visual liquidity for Singaporean consumers (***Figure 6***).

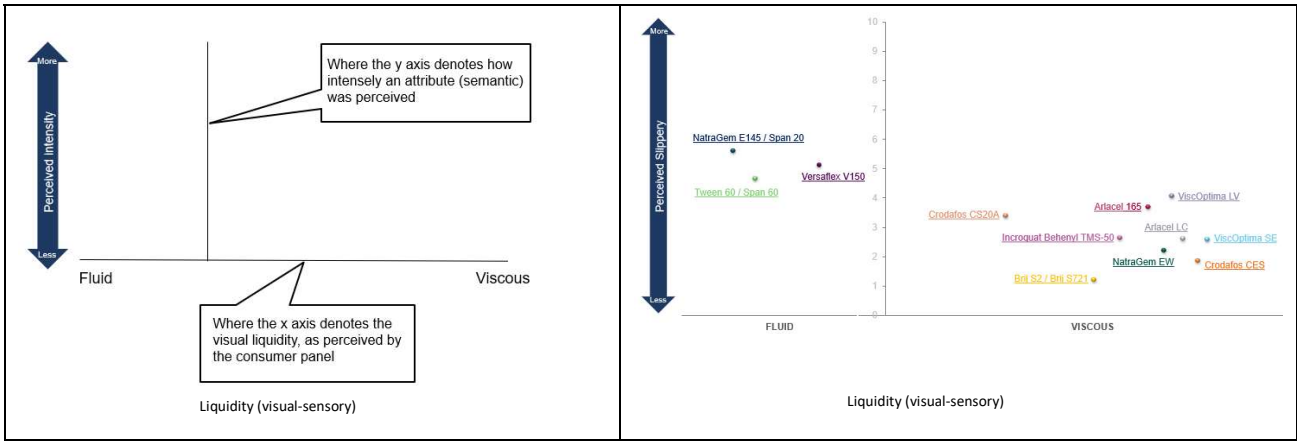

Figure 6 : *A schematic Matrix diagram on the left, showing the fluidity as the x-axis and perceived intensity of Semantics on the y-axis. Matrix diagram on the right demonstrating the position of 12 simple formulations for "slippery" across visual liquidity assessment (@Play stage) for Singaporean consumers*

Discussion.

In this section, we will investigate the language wheels from Singapore and France a little further. By referring to ***Figure 3***, we find some common attributes such as creamy, greasy, thick, sticky, light and fresh from each wheel. They were used by both consumer set and they tend to relate well. For example, when a Singaporean consumer describes a sample as thick, creamy or light, then a French consumer is also likely to use the same language to describe such a formula. This relatability indicates similarities in language use but does not mean that these consumer groups would rate the same formulation of equal intensity, in terms of thickness, creaminess and lightness.

In the earlier section, sensorial preference drivers for both the Singaporean and the French consumer were also highlighted. It was found that “fresh”/ “frais” (in French) was a top preference driver for each consumer group. Based on the insights generated, the meaning of the word ‘fresh’ is quite similar for both groups, however there are variances in expectation, thus leading to a different oil-in-water emulsifier system being recommended to meet the optimal requirement of ‘fresh’ or ‘frais’ for the Singaporean and French consumer, respectively (***Figure 7***).

We can see that Versaflex V150 was perceived by the Singaporean consumer as the most fresh, and Brij S2/S721 as the least fresh. On a contrary, Arlacel 165 was perceived by the French consumer as the most fresh, and Brij S2/S721 as the least fresh. Freshness correlates with the technical descriptor/Syntax ‘Wetness’. NatraGem E145/Span 20, would have rated highest in terms of wetness, had we relied on technical Syntax, rather than on our consumer insights. Brij S2/S721 as you can see the least fresh or least wet feeling formulation. This show the importance of consumer language and the focus being on the consumer expectations.

Another interesting attribute is ‘Rich’ for the Singaporean consumer and ‘Riche’ for the French consumer (***Figure 7***). These descriptors may appear similar; however they have different meanings to each group, thus resulting in various recommended emulsifier systems. ViscOptima LV was perceived by the Singaporean consumer as the most “rich”, and Versaflex V150 as the least rich. Brij S2/Brij S721, in contrast, was perceived by the French consumer as the most rich, with the Tween 60/Span 60 system as the least rich. Rich correlates with the technical descriptor/Syntax “Greasy”, “Thick” and “Waxy”. This means that the formulator would have these terms in mind and likely use the Brij system to formulate a ‘rich’ formula, since this system is the highest in terms of greasiness, thickness and waxiness. In this case, the French consumer Semantic is more aligned with the technical Syntax, with the Brij system the highest in terms of greasiness, thickness and waxiness. This reinforces the importance of understanding the expectations of the consumer for whom the formulation is being created.

greasy

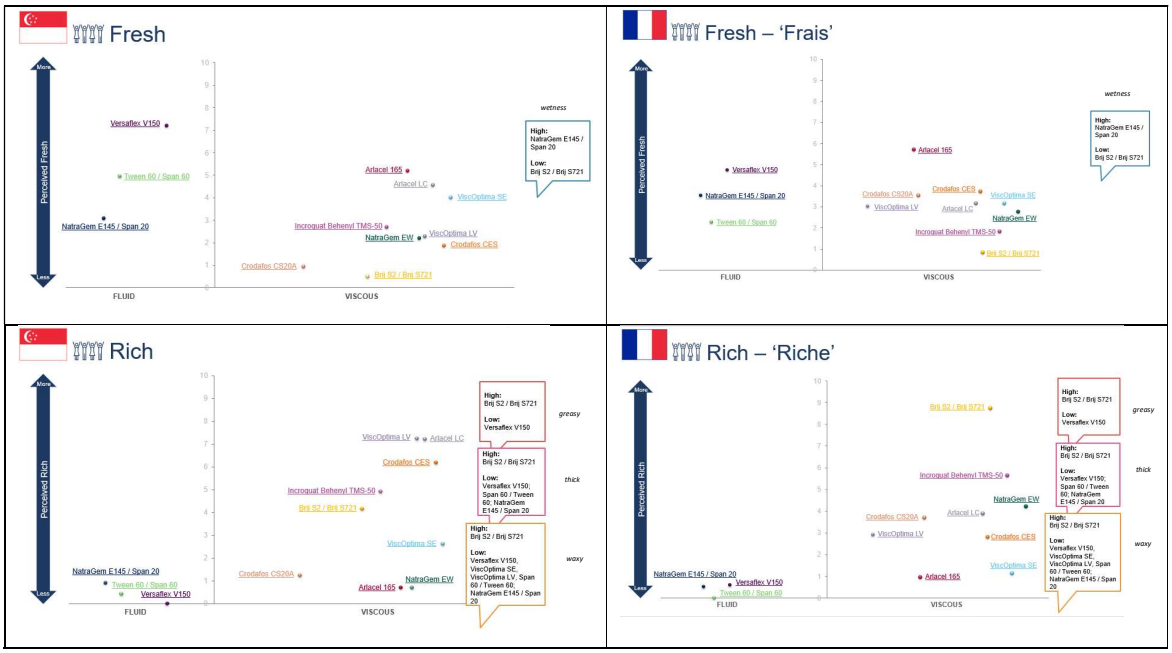

Figure 7 : *Matrix diagram demonstrating the position of 12 simple formulations for "Fresh" and "Rich" across visual liquidity assessment (@Play stage) for Singaporean and French consumers, respectively*

To exploit this valuable data to its full potential, the SenStories™ Selector tool has been developed, which enables predictive ingredient selection by allowing the user to discover oil-in-water emulsifier systems based on the consumer desired sensory. ***Figure 8*** shows the image of the SenStories™ Selector tool [5]. To use this tool, the consumer set to be explored (France or Singapore) will first be selected. Then one or two Semantics (consumer language descriptors) will be selected to for the formulation to meet. Next, any of the necessary refinement options can be selected, before selecting submit. A list of recommended emulsifiers will then be displayed.

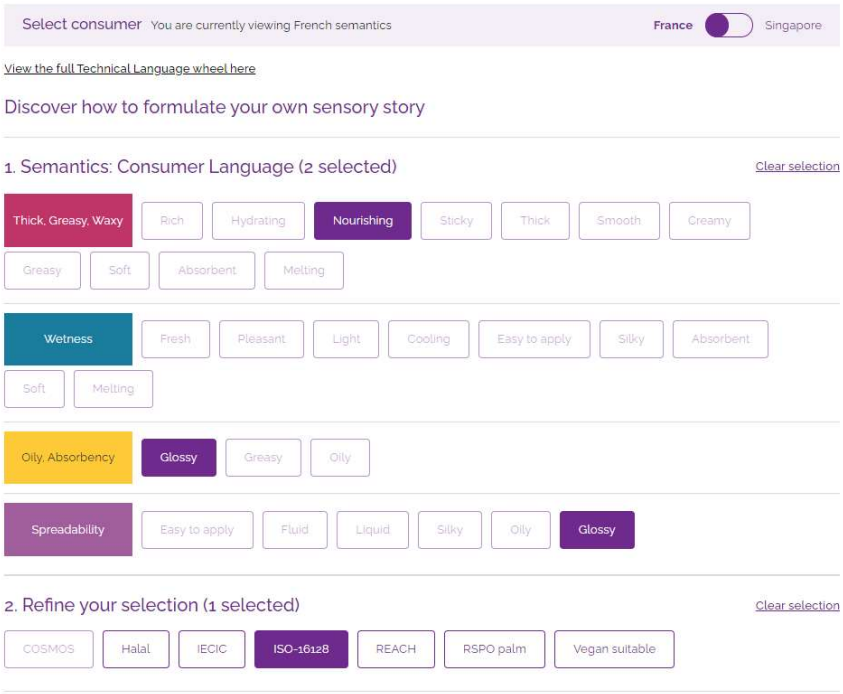

Figure 8 : *An image of SenStories™ Selector tool that helps users to discover suitable oil-in-water emulsifier system recommendations for the development of skin care formulations with targeted sensories.*

Conclusion

We have successfully bridged consumer and technical sensory perspective on characterization of skin care products, in particular oil-in-water emulsifiers, using two groups of consumers - Singaporean and French. We have gained an understanding how the 2 consumer groups perceived the sensory characteristics of some simple skin care formulations and how the consumer language (Semantics) correlate to technical sensory language (Syntax).

Apart from developing a consumer lexicon for each consumer region group, the study has shown that there is a good agreement between consumer and trained panel for both Singaporean and French consumers, based on their RV values. The study has also enabled us to understand the importance of consumer language; and having the focus being on the consumer expectations to select the appropriate emulsifier systems. We also have a web-based search tool - The SenStories^{TM} Selector which has been designed with consumer expectations (from Singapore and France) to help customers/users discover suitable oil-in-water emulsifier system recommendations, for the development of skin care formulations with targeted sensories. The SenStories^{TM} tool will allow the technical team to translate the marketing brief into a selection

of emulsifier to reach the desire sensory and to understand which technical attribute must be considered to match the "sensory claim". This SenStories™ methodology and the tool can be configured to other consumer groups and ingredient types.

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Conflict of Interest Statement. NONE.

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