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Esthetic Influence of Negative Space in the Buccal Corridor during Smiling

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ABSTRACT

The purpose of this study was to measure and verify the esthetic influence of the bilateral spaces between maxillary teeth and lip corners, called negative space (NS), during smile. The sample was comprised of 60 smile photographs obtained from 60 individuals (30 men and 30 women) aged 18 to 25 years old. Two orthodontists and two lay people evaluated these pictures regarding esthetics by a visual analogue scale. In each picture, the right and left NS were measured in millimeters and in proportion to the smile width (SW). Data were analyzed for statistical significance ($P = .05$). The mean NS of the sample was 6.68 ± 1.99 mm, and the NS proportion in relation to the SW was $9.6 \pm 2.56\%$, for both sides of the arch. No significant asymmetries were observed between the right and left sides. The NS was significantly larger in men than in women when measured in millimeters ($P = .028$) (7.08 ± 2.24 mm in men vs 6.28 ± 1.62 mm in women), but the NS proportion to the SW was similar ($9.94 \pm 2.24\%$ in men vs $9.26 \pm 1.61\%$ in women). When the 12 individuals with the smallest NS in proportion to SW were compared with the 12 individuals with the largest NS in proportion to SW, there was no statistical difference regarding the esthetic evaluation ($P = .11$). It was concluded that the NS did not influence the esthetic evaluation of smile photographs in the sample in this study, for both orthodontists and lay people.

KEY WORDS: Esthetic, Negative space, Smile.

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The face is the most important individual factor determining the physical appearance of people; the mouth and teeth are considered fundamental in facial esthetics.^{1,2} Therefore, it is essential to control the esthetic effects caused by orthodontic treatment, which is only possible by knowing the principles that manage the balance between teeth and soft tissues during smile.^{3,4} Consequently, more thorough studies are required on the details that can influence the esthetic balance between teeth and soft tissues.

During a smile, bilateral spaces appear between the buccal surface of the most visible maxillary posterior teeth and the lip commissure, called negative spaces (NSs), black spaces, or buccal corridor.⁵⁻⁹ The purpose of this study was to verify the influence of the NS on the smile esthetics, ie, whether individuals with larger or smaller NS have altered esthetics because of this factor. This study also measured the NS during smile in millimeters and in percentage in relation to the smile width (SW), assessing any differences between sexes, assessing presence of asymmetries, and establishing a pattern for diagnosis and clinical evaluation of deviations of this measurement from


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
Sixty photographs obtained from 60 subjects (30 men and 30 women) were used in this study. All subjects presented a complete permanent dentition with the possible exception of third molars. The sample was selected among dental students at the Federal University of Santa Catarina, Florianópolis, Brazil, and included white individuals aged 18 to 25 years, with good dental alignment in both arches, balance between the facial thirds, and spontaneous lip seal. All individuals had not been treated orthodontically and signed an informed consent form approved by the university ethics committee.

Frontal view photographs were taken of the lower facial third, including the nose tip and chin. The individuals were photographed at forced smile because it is more easily reproduced,¹⁰⁻¹² seated with the cephalostat positioned at 90 cm from the camera and in natural head position.^{10,13-16} A metallic millimeter ruler (Kawasa Manufacturer, Tokyo, Japan) was positioned close to the lip commissure as a scale. Pictures were taken in the same closed environment under the same light conditions with a CoolPix 950 digital camera (Nikon, Japan) at 2000 pixels of resolution.


After the photographs were completed the SW, right and left negative spaces (RNS and LNS, respectively), and the proportion of NS to the total SW were measured, following the methods of Hulsey⁷ and Johnson and Smith.⁹ A line was projected between the lip commissures (right and left cheilion points), and the maximum width of the mouth during smile was measured in millimeters. The distance between the most buccal lateral points of the maxillary teeth, perpendicular to the SW lined up to the right and left lip commissures, was measured, representing the RNS and LNS ([Figure 1](#) ). On the basis of the SW and RNS and LNS measurements in millimeters, the percentage of RNS and LNS in relation to the SW during smile was derived. The program UTHSCSA (University of Texas Health Science Center at San Antonio) ImageTool for Windows version 1.21 (Copyright 1995–1996) was used for measurement of the digitized photographs.


An album was assembled with the 60 black-and-white smile printed photographs, showing only the mouth area, including the lips, teeth, and intraoral visible structures, to avoid interference from other facial structures, such as the nose and chin.

The esthetic evaluation was carried out by two orthodontists and two lay people (called examiners) by analysis of all photographs, using the visual analog scale (VAS)^{1,17} supplied below each photograph. The VAS varies progressively in values from esthetically very poor, poor, neutral, good, to very good. Each examiner was asked to mark on the VAS a point on which the smile was closest to the correspondent value of the VAS, as observed in [Figure 2](#) . After each examiner completed the esthetic evaluations, the points marked on the VAS were converted into grades from 0 to 10, 0 being the minimum esthetic value and 10 the maximum esthetic value. Two weeks after the first evaluation of the album, each examiner received a second album with the same photographs in a different arrangement. The mean of the two evaluations was used as a final esthetic grade for each photograph.

After the examiners evaluated esthetically the 60 photographs, the 12 photographs with the smallest NS (group G1) were statistically compared with the 12 photographs with the largest NS (group G2). [Figure 3](#)  shows examples of the photographs used in the study. Thus, it was observed whether the smile photographs with the largest NS presented statistically different esthetic grades than the photographs with the smallest NS.

To verify whether there was a statistical difference in the NS between sexes and between the right and left sides, the sample was divided in relation to the means and standard deviations.

To verify the calibration of the investigator conducting the measurements, SW and NS measurements were achieved in millimeters on 10 photographs of the sample at two distinct periods with a 15-day interval. As observed in [Table 1](#) , the investigator presented a good calibration for achieving the measurements addressed in this study because statistically similar means and variances were achieved for each measurement at the two periods of measurements.

To verify the reproducibility of the smile photographs, ie, whether the forced smile may be repeated with the same expression by the same individual at another period and thus be used as a method for comparison, two series of photographs were taken on different days (30-day interval) of 10 individuals of the sample. The SW and the bilateral NS were measured in millimeters and are shown in [Table 2](#) , which revealed that the individuals included in the sample repeated the same dimensions of forced smile on the first and second photographs.

To investigate the differences between sexes and asymmetry regarding the NS during forced smile, the two-way parametric analysis of variance and the Tukey test were applied to check any possible significant differences. Investigation of the esthetics of forced smile was performed by the three-way (side, sex, and examiner) parametric analysis of variance and the Tukey test to detect any possible significant differences. The region of rejection of the hypotheses inherent to each type of statistical analysis was constructed at the 0.05 level.

[Table 3](#) shows the NS frequency, means, and standard deviations in millimeters according to sex, right and left sides, and for the total sample. The mean values of the NS in millimeters according to sex and right and left sides are shown in [Figure 4](#).

[Table 4](#) shows the NS frequency, means, and standard deviations in percentage according to sex, right and left sides, and for the total sample. The mean values of the NS in percentage according to sex and right and left sides are shown in [Figure 5](#).

The frequencies, means, standard deviations, and statistic groups for the esthetic evaluations according to the factors examiner and group, are exhibited in [Table 5](#). The mean values of the esthetic evaluations (grades) assigned by each examiner to groups G1 and G2 and mean of the evaluations of all four examiners are shown in [Figure 6](#).

[Table 6](#) shows the esthetic mean scores and standard deviations assigned by each examiner for groups G1 and G2, as analyzed by the Tukey test. [Figure 7](#) shows the esthetic means assigned by each examiner individually for groups G1 and G2.

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The mean NS during forced smile for the total sample was 6.68 ± 1.99 mm for each side ([Table 3](#)). In proportion to SW, the mean value was $9.60 \pm 2.56\%$ for each side ([Table 4](#)). Considering both sides of the dental arch, this study found a value of 19.20% for the proportion of NS to SW, larger than the 9% for cases treated with extraction of premolars and 8% for cases treated without extractions found by Johnson and Smith,⁹ with no quantitative or esthetic difference between groups. The large difference between the results of this study and the findings of Johnson and Smith can be attributed to the type of smile analyzed, namely, forced smile in the present study because of the easier reproduction and natural smile in the study of Johnson and Smith,⁹ which is more difficult to reproduce.^{4,18,19}

Rigsbee et al¹¹ found proportions of 40% for NS in an orthodontically treated group, and 42% for a nonorthodontically treated group, with no statistical difference between these groups. However, these authors measured the NS by Hulse's⁷ method considering the distance between the maxillary canines as the lateral limit of the maxillary arch. Using Hulse's⁷ method, Johnson and Smith⁹ did not find any difference in the proportion of intercanine distance SW between cases treated without (29%) or with (28%) extraction of premolars. Because of the different methodologies used, comparison of the results of this study with those of Rigsbee et al¹¹ and Johnson and Smith⁹ is limited.

Another factor that may have influenced the results, causing this difference between studies, is the light conditions under which the photographs are taken. Because teeth are positioned more posteriorly in the buccal corridor, light becomes reduced, which causes a gradual darkening and consequently less observation of these posterior teeth.⁴ The less-illuminated the photograph, the larger will be the NS because less teeth will be observed, thus reducing the arch width, whereas the SW is the same. Therefore, there may have been differences in the standardization of light conditions between studies, impairing comparison between them.

According to the literature, an esthetically pleasing smile usually shows symmetry and proportion between teeth, gingiva, and lips.^{3,15,20,21} The position of the mouth corners or lip commissures also affects the smile symmetry, and there must be regressive proportion of the teeth exposure created by curvature of the dentoalveolar arch.⁸ There are no specific studies on asymmetries related to the NS.

[Table 3](#) and [Figure 4](#) show that the means of the right ($6.52 \text{ mm} \pm 1.97$) and left ($6.84 \text{ mm} \pm 2$) sides of the NS did not show significant differences ($P > .05$). The mean NS proportion to SW was $9.32 \pm 2.37\%$ for the right side and $9.87 \pm 2.44\%$ for the left side ([Figure 5](#); [Table 4](#)), with no statistical difference between these values. These results show presence of symmetry between the right and left sides regarding the NS in the present study.

Few studies in the literature have investigated whether there is any difference in the NS between males and females. [Table 3](#) shows that the resultant mean NS, on each side, was 6.28 ± 1.62 mm for the women and 7.08 ± 2.24 mm for the men. This was evidence that there was a statistically larger NS in millimeters for the men compared with the women ($P < .05$). On the other hand, the proportion of NS to SW on each side was $9.94 \pm 2.24\%$ for the men and $9.26 \pm 1.61\%$ for the women ([Figure 5](#); [Table 4](#)), which was not statistically significant ($P > .05$). This demonstrated that the men in this study presented a statistically larger NS than the women, yet this difference was not significant in terms of percentage. This indicates proportionality of the NS to SW size between sexes, with men showing larger NS dimensions.

[Table 3](#) shows the mean NS in millimeters for the right and left sides, for both sexes, as shown in [Figure 4](#). The statistical analysis reveals that the possible interaction between side and sex was not significant ($P > .05$). The interaction between the right and left sides and sex was also investigated for the NS measurements in percentage to SW, and the means and standard deviations shown in [Table 4](#) and [Figure 5](#) also reveal no statistically significant interaction of the factors side and sex ($P > .05$).

Therefore, in samples of this study, there was evidence demonstrating that for both men and women, the mean NS was statistically similar for the right and left sides. Similarly, for both right and left sides, the men presented the largest NS in millimeters, yet equal in

percentage to the SW as in the women.

[Table 5](#) shows the frequency, means, standard deviations, and statistic groups for the esthetic evaluations of the photographs of groups G1 and G2, according to examiner and group. The Tukey test revealed that examiner O2 (lay individual) assigned the highest esthetic score (6.887—group A); examiners O1 (lay individual) and O4 (orthodontist) assigned the same mean scores (5.498 and 5.579, respectively— group B); and examiner O3 (orthodontist) assigned the lowest esthetic score (4.446—group D). A $P < .05$ value was associated to the examiner factor, which was evidence that examiners did not assign equal esthetic scores, regardless of the group factor. Despite this difference between the criteria and parameters adopted by the examiners for the esthetic evaluation, the examiners showed constancy in their evaluations at periods 1 and 2, revealing that all examiners kept their own criteria for esthetic evaluation at different moments ([Table 5](#)).

The mean values of the esthetic evaluations assigned to the photographs in group G1 (smaller NS) and group G2 (larger NS) by examiners are shown on [Table 5](#) ([Figure 6](#)). The Tukey test applied for the group factor evidenced that groups G1 and G2 belonged to the same statistic group. Thus, there was no statistical difference in the esthetic evaluations between the groups with larger and smaller NS, meaning that, in this sample, the NS cannot be considered a factor that influenced the esthetic evaluations, regardless of the examiner factor.

Some authors agree that the size of NS is not esthetically critical, provided it is within the typical limits of individual differences.^{5,6,9} However, these authors did not provide information regarding the extent of this limit, therefore impairing adequate evaluation.

On the other hand, other authors believe that it is important to achieve adequate NS and minimize the black spaces at the mouth corners.^{11,19,22} Rufenacht⁸ recommends adequate restoration of the lateral NS, allowing smile characterization in conformity with the individual personality, yet also did not specify the adequate size or proportion of the NS. Some studies also demonstrated that broader smiles, showing more posterior teeth, are considered more pleasant than a smile that shows less posterior teeth.^{15,23–25} In this study, however, the NS proportion did not influence the esthetic evaluations, regardless of the examiner factor.

[Table 6](#) exhibits the means and standard deviations assigned to groups G1 and G2, according to the judgment of each examiner ([Figure 7](#)). The Tukey test revealed that each examiner assigned equal mean esthetic scores for groups G1 (smallest NS) and G2 (largest NS), meaning that all examiners considered groups G1 and G2 statistically identical regarding the proportion of NS to SW, confirming the lack of influence of the NS on the esthetic evaluation of this sample. Therefore, this study revealed that both orthodontists and lay people did not consider the NS a significant factor influencing their esthetic evaluations in this sample.

CONCLUSIONS [Return to TOC](#)

- The mean NS for each side was 6.68 mm (± 1.99).
- In proportion to the distance between the lip commissures, the mean NS for each side was 9.60% (± 2.56).
- There was symmetry of the NS between the right and left sides.
- The men showed a statistically larger NS than the women, yet the percentage difference was not significant.
- The NS did not influence the esthetic evaluations of the smile photographs.
- Orthodontists and lay people did not consider the NS as an important factor influencing their esthetic evaluations.
- More studies on lip-teeth relationship are required to help understand the NS influence on smile esthetics.

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TABLES [Return to TOC](#)

TABLE 1. Frequency, Mean, and SD of the Examiner Calibration, in Two Moments^a

Measurements (mm)	Moment	Frequency	Mean	SD	<i>P</i>
SW	1	10	62.987	4.357	.369 NS ^b
	2	10	64.793	5.008	
RNS	1	10	5.496	2.035	.876 NS
	2	10	6.005	1.842	
LNS	1	10	5.937	1.778	.914 NS
	2	10	6.278	1.799	

^a SW indicates smile width; RNS, right negative space; and LNS, left negative space.

^b NS indicates not significant ($P > .05$).

TABLE 2. Frequency, Mean, and SD of the SW, RNS, and LNS Measurements in Two Moments for the Photograph Repeatability Test^a

Measurements (mm)	Moment	Frequency	Mean	SD	<i>P</i>
SW	1	10	69.283	6.377	.760 NS ^b
	2	10	67.995	6.050	
RNS	1	10	7.328	1.762	.315 NS
	2	10	7.173	1.500	
LNS	1	10	7.405	2.482	.341 NS
	2	10	7.141	2.004	

^a SW indicates smile width; RNS, right negative space; and LNS, left negative space.

^b NS indicates not significant ($P > .05$).

TABLE 3. Negative Space Frequency, Mean, and SD in Millimeters, by Sex and Side in Total Sample

Factors	Frequency	Mean	SD	<i>P</i>
Sides				
Right	60	6.521	1.972	.373 NS ^a
Left	60	6.842	2.005	
Sex				
Women	60	6.281	1.624	.028*
Men	60	7.082	2.245	
Total sample	60	6.681	1.995	

^a NS indicates not significant ($P > .05$).

* significant ($P < .05$).

TABLE 4. Negative Space Frequency, Mean, and SD in Percentage, by Sex and Side

Factor	Frequency	Mean	SD	<i>P</i>
Side				
Right	60	9.329	1.972	.214 NS ^a
Left	60	9.878	2.005	
Sex				
Women	60	9.262	1.611	.123 NS
Men	60	9.945	2.245	
Total sample	60	9.603	2.566	

^a NS indicates not significant ($P > .05$).

TABLE 5. Frequency, Mean, SD, and Statistical Groups (S. Gr.) for Esthetic Evaluations by Moment, Examiner, and Group Factors

Factors	Frequency	Mean	SD	S. Gr.	P
Moment					
1	48	5.674	1.545	A	.157 NS ^a
2	48	5.531	1.697	A	
Examiner					
O1	24	5.498	1.653	B	.001***
O2	24	6.887	1.164	A	
O3	24	4.446	1.282	C	
O4	24	5.579	1.137	B	
Group					
1	48	5.820	1.119	A	.110 NS
2	48	5.385	1.491	A	

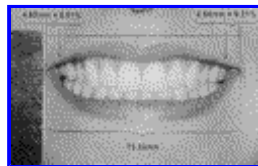
^a NS indicates not significant ($P > .05$).

*** significant ($P = .001$).

TABLE 6. Esthetic Score's Mean, SD, and Statistical Groups (S.Gr.) for Groups G1 and G2 Attributed by Each Examiner

Examiner	Group	Mean	SD	S. Gr.
1	G1	5.809	1.550	A
	G2	5.187	1.760	A
2	G1	7.040	1.127	A
	G2	6.734	1.229	A
3	G1	4.481	1.579	A
	G2	4.412	0.914	A
4	G1	5.952	1.198	A
	G2	5.206	0.976	A

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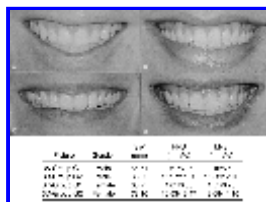
Click on thumbnail for full-sized image.

FIGURE 1. Method used to measure the smile width and right and left negative spaces in millimeters and in percentage



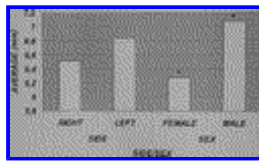
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FIGURE 2. Example of demarcation of the visual analog scale used for evaluation by the examiners



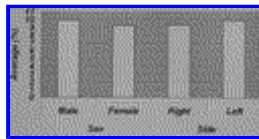
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FIGURE 3. Examples of the pictures used in the study. Pictures 3A and 3C have smaller NS in millimeters and in proportion to SW (group G1), and pictures 3B and 3D have larger NS (group G2), as described below



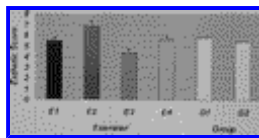
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FIGURE 4. Mean of negative space in millimeters and by sex and side (* $P < .05$)



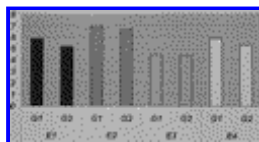
Click on thumbnail for full-sized image.

FIGURE 5. Mean of negative space in percentage in relation to the smile width, by sex and side



Click on thumbnail for full-sized image.

FIGURE 6. Mean esthetic scores attributed by each examiner for groups G1 and G2 together, and mean esthetic scores attributed to groups G1 and G2 by all examiners together (* $P < .05$)



Click on thumbnail for full-sized image.

FIGURE 7. Esthetic means attributed by each examiner for groups 1 and 2

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