Spatial frequencies for accurate categorization and discrimination of facial expressions

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Context

Many studies have examined the role of spatial frequencies (SFs) in facial expression recognition. However, most of these studies used arbitrary cut-off to isolate the impact of low and high SFs[1] thus removing possible contribution of mid-SFs. Considering that mid-SFs are important for accurate face identification(2), it is of particular interest to include them to gain a full understanding of the role of SFs in emotion perception. To this aim, the SFs Bubbles method[2] was used in order to reveal the diagnostic SFs for the perception of facial expression.

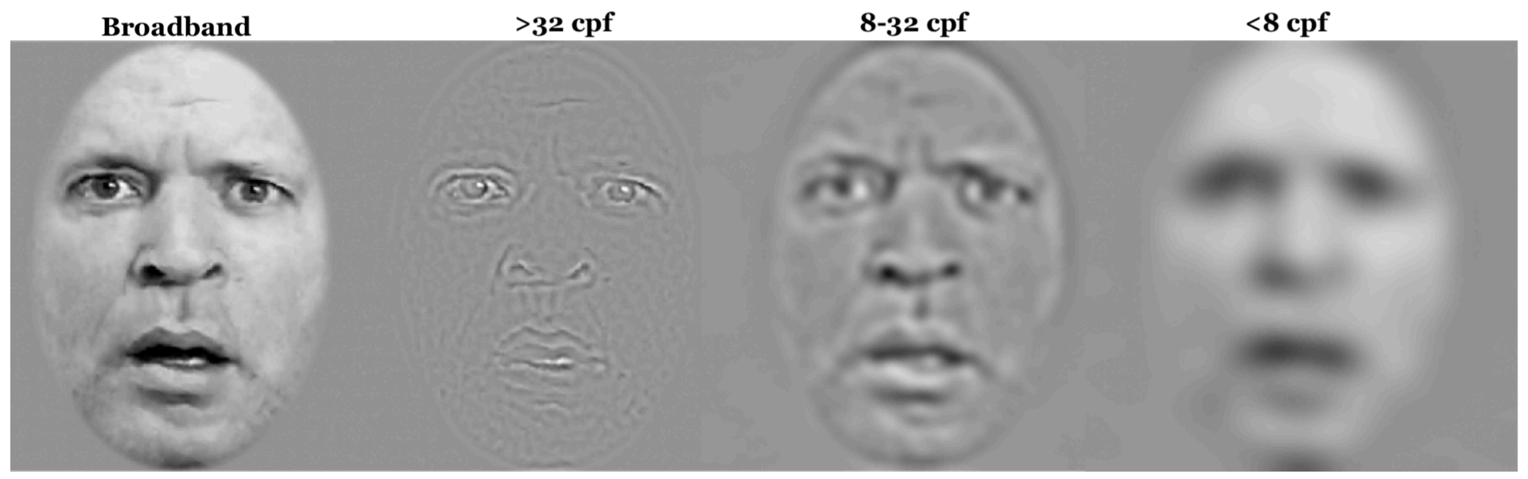

Figure 1 – Example of stimuli used to investigate the role of high SFs (> 32 cycle/face) and low SFs (<8 cycle/face) in experiments conducted on facial expression perception and spatial frequencies. Note that Mid-SFs (8-32 cycle/face) are usually not included in these experiments.

Method

Forty participants were tested; 20 in an 8-expressions categorization task and 20 in a discrimination task (4200 trials per participant). Both tasks included the 6 basic emotions as well as neutral and pain (see Guérette et al., poster 346 for the results on pain). In the categorization task, subjects were asked to identify the perceived emotion among all the alternatives. In the discrimination task, subjects were asked, in a block-design setting (block order was counterbalanced across participants), to discriminate between a target emotion (e.g. fear) and all other emotions. Mean accuracy was maintained halfway between chance (i.e. 12.5% and 50% correct for each task, respectively) and perfect accuracy using QUEST. [3]

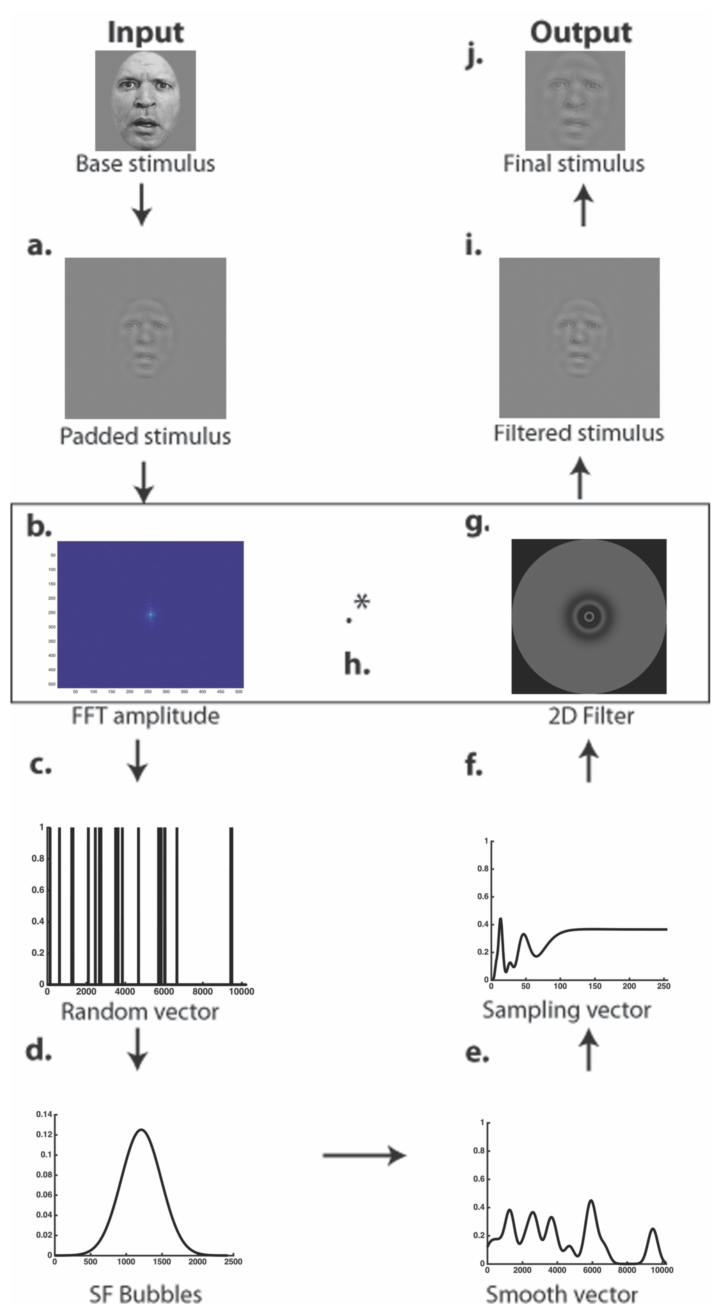

Figure 2 – Procedure for creating a stimulus with the frequency bubble method.

Classification vectors

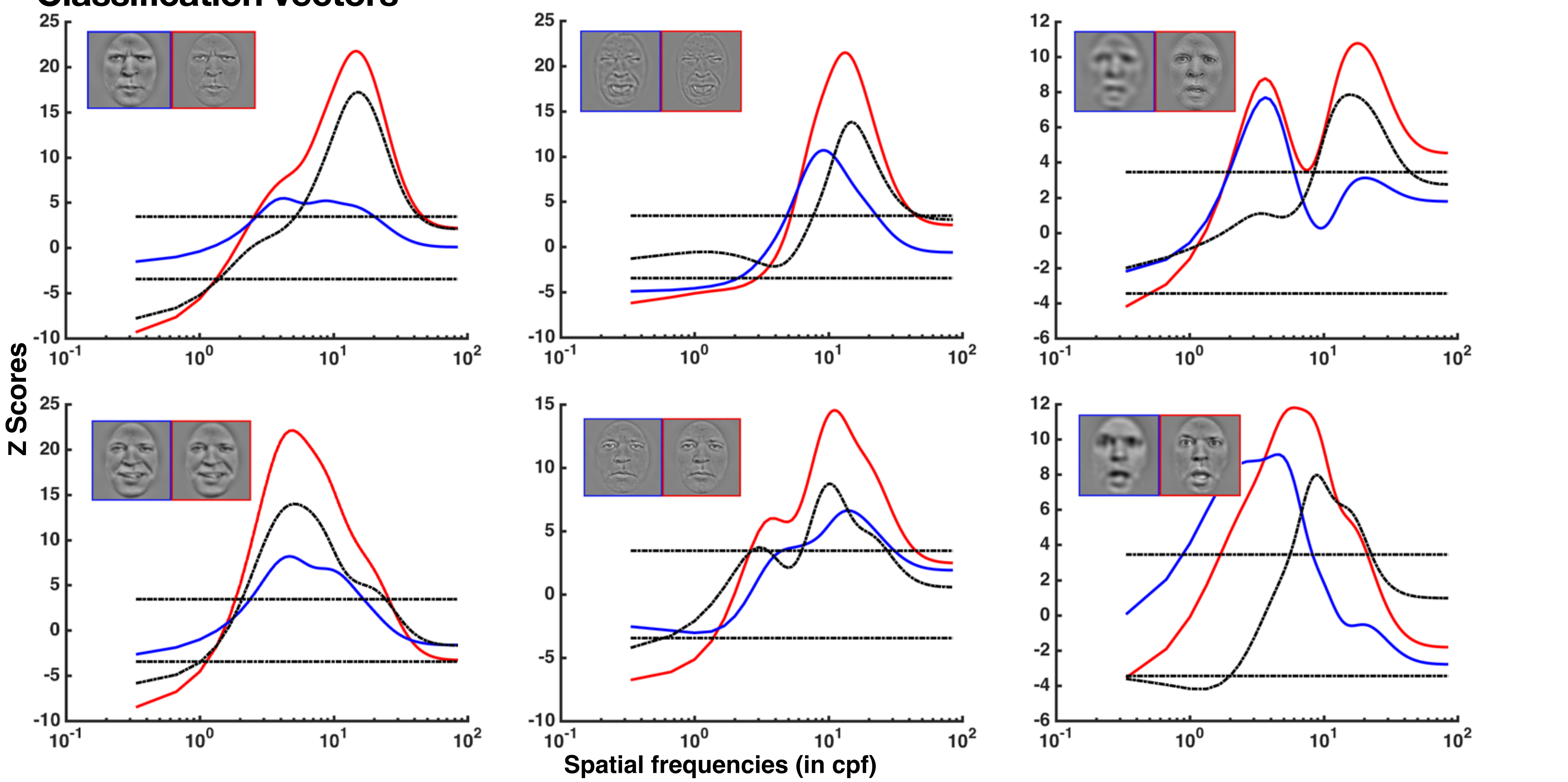

Figure 3 – Spatial frequencies correlated with subjects' accuracy for the categorization task (red line) and for the discrimination task (blue line) for the six basic emotions (e.g. anger, disgust, fear, happiness, sadness, and surprise). The difference observed between the two tasks is shown by the black dotted line. The two faces at the top of each graph show the spatial frequencies that reached statistical significance in both tasks. Zcrit for all analysis = 3.45 ($p < .05$).

Analysis

SF tunings were obtained by conducting what amount to multiple regression analysis on the SF filters and accuracies across trials. A weighted sum of SF filters was calculated by allocating positive or negative weights (z-scored accuracies) to filters that led to correct/incorrect responses, respectively.

Results

In both tasks, accuracy for the facial expression of happiness and surprise is associated with low-SFs (peaking at around 5 cpf) whereas accuracy for disgust and sadness is associated with mid-SFs (peaking at 11 and 12.5 cpf for both tasks). Interestingly, the facial expression of fear and anger reveal significantly different patterns of use across tasks. Whereas their correct categorization is correlated with the presence of mid-to-high SFs (peaking at 15 and 18 cpf for angry and fear, respectively) their accurate discrimination is correlated with the utilization of lower SFs (peaking at 4 and 3.7 cpf).

Discussion and Conclusion

Our results highlight the importance of the mid-SFs in the visual processing of many facial expressions as it is found for accurate face recognition[2]. Importantly, it suggests that any method removing mid-SFs offers an incomplete account of SFs diagnosticity for facial expression recognition. Moreover, the different pattern of use of SFs across tasks for facial expressions representing social threatening cues (e.g. angry and fear) suggests that the visual system is able to use low-SF information to detect and discriminate them, but that higher-SFs are probably necessary in a multiple-choice categorization task to allow fine-grained discrimination.

References

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