Complementary methodologies to investigate spatial frequencies in facial expression recognition

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Theoretical context
Most of the studies on facial expression recognition have used arbitrary cut-off to isolate the impact of different range of spatial frequencies (SFs; Fig. 1a). For example, two studies1,2 revealed that low SFs play a central role in the recognition of pain. However, our own work using the Bubbles method3 suggests that pain categorization relies on mid-to-high SFs4, a SF range that has been disregarded in previous studies. Using a more ecological method that simulates the distance of stimuli presentation5, we also revealed that pain recognition is optimal in a short to medium distance (1.2-4.8 m)6 Here we were interested in the generalization of these results for other basic expressions using these two complementary methodologies.

Method
40 participants took part in the experiments (18-35 years old; M = 23, SD = 3.46). Both tasks consisted of an 8-expression categorization task using the STOIC facial expression database (six basic expressions, neutral and pain; see ref. 4 for data on pain). Mean accuracy was maintained halfway between chance (i.e. 12.5% and 50% correct for each task, respectively) and perfect accuracy using QUEST4.

SF Bubble’s method2 (experiment 1)
- A data-driven method which randomly samples SFs on each trial to reveal the useful visual information for facial expression recognition (Fig. 1b).

Distance method (experiment 2)
- Presentation of reduced size images simulating increasing viewing distance using the Laplacian Pyramid toolbox4 (Fig. 2).

Analyses and results
For experiment 1, multiple regression analysis on the SF filters and accuracies across trials were computed. SF peaks were measured by submitting the classification vector to a 50% area SF measure (ASFM; Fig 3a). For experiment 2, unbiased hit rates7 were computed to quantify performance at each distance (Fig. 3b). The relationship between the two methodologies is linear. That is, SF tuning for all basic facial expressions, except for surprise, falls into the mid SF range and a drop in performance occurs when the simulated distance no longer reveals mid SFs. We used curve fitting analyses to verify the point of subjective equality (PSE) and the slope of each facial expression. Repeated measures ANOVAs on PSE and slope revealed a significant effect of facial expression (PSE = F(6, 114) = 45.057, p < .001; slope = F(6, 108) = 30.668, p < .001) and follow-up paired sample t-tests (corrected p = 0.05/21) revealed significant differences between expressions. For example, surprise is found to be the least sensitive expression to the effect of distance (M = 0.69 ± 0.14) which is consistent with its lower SF peak.

Conclusion
Similarly, for pain, results suggest that recognition of basic facial expressions relies on mid SFs with the exception of surprise. These results are consistent with surprise being characterized as having a rich low SF signal and considered as a distal facial expression8. Finally, this study highlights the relevance of using complementary methodologies to investigate SFs in facial expression recognition, but foremost, that any study that excludes mid SFs cannot capture an accurate profile of the role of SFs in these tasks.

References