# REFLETS: Rétroaction Émotionnelle Faciale et Linguistique, et États de stress post-Traumatiques
Emotional Facial and Linguistics feedback, and Post-Traumatic Stress States

I. Contexte, positionnement et objectif(s) de la proposition

The theory of peripheral emotional feedback – that our emotional experiences are under the retroactive influence of our own expressions – has been an ongoing subject of debate in psychology since William James (1890, Niedenthal et al, 2010). On the one hand, the fact that putting on a smile or a frown may have an implicit, automatic effect in one's emotional experience holds **tremendous potential for clinical remediation** in psychiatric disorders (an estimated 40-75% of which are linked to problems of emotional regulation - Gross & Jazaieri, 2014). On the other hand, the idea faces **tremendous theoretical and methodological challenges**: in July 2016, a 17-laboratory Registered Replication Report (Wagenmakers et al, in press) failed to reproduce the effect found by one of the seminal paper of the field, Strack, Martin, and Stepper (1988), despite that original study being cited 1459 times (Google Scholar, Oct. 2016).

Project REFLETS aims to address this situation head-on, building **new health technology able to channel the psychological mechanism of facial and vocal emotional feedback for clinical application to post-traumatic stress disorders** (PTSD). To do so, project REFLETS combines significant research strengths in the three fields of computer science (audio/visual signal processing ; lead by a team ranking first in two international challenges in facial emotion recognition), cognitive psychology (affective and social neuroscience ; lead by a team funded by an ERC grant), and clinical psychology (human factors and post-traumatic stress disorders ; lead by the French Army Medical Institute), in addition to support for design and product development from one of the major player of the luxury industry (Chanel).
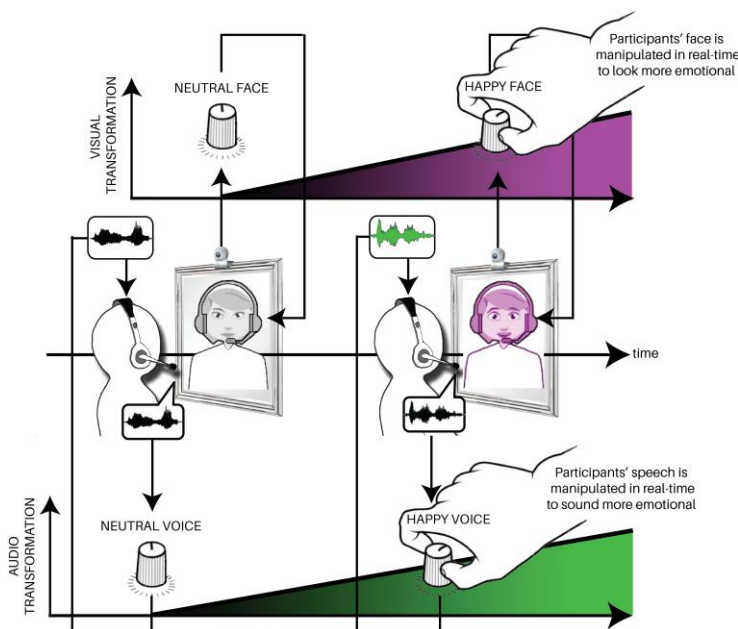
The project's central technology is a computer-augmented mirror, in which observers both see and hear themselves in a gradually more positive way: without their knowing, their reflected face (captured by a camera) is algorithmically and photo-realistically transformed to appear more smiling, and their speech (captured by a microphone) is re-synthesized to seem more happy and relaxed. Using the mirror, we hypothesize that observers will come to believe the emotional tone of their transformed facial and vocal reflection as their own, and align their feelings with the transformation. Clinically, we propose to use this mechanism to remediate emotional numbing in post-traumatic stress disorder (PTSD) patients (see Aucouturier et al., 2016 for a recent proof of concept)

Project REFLETS will reach three major objectives, original with respect to each of its core disciplines:

1. **Realistic, real-time, multimodal synthesis of emotional expressions.** The project goes beyond the field's state-of-art in photo- (and phono-) realism by producing audiovisual expressions that the speakers themselves will believe are their own, and in real-time performance by doing so with feedback latencies that will not disrupt ongoing speech (a few tens of milliseconds). To do so, we will develop a unified audiovisual deformation model, based on control points in the triangulated facial

geometry (Soladié et al., 2013) and in the spectral envelope of the speech signal (Aucouturier et al., 2016). The most important risk with this objective is that the system does not achieve latencies fast enough for sensorimotor feedback; it can be addressed by changing the use-case to a skype-like dual-video system, for which longer real-time latencies are better-accepted.

2. **Non-intrusive audiovisual peripheral emotional feedback:** Using the augmented mirror, we will conduct cognitive psychology experiments in the vein of Aucouturier et al. (2016), to establish the methodological conditions of a strong emotional feedback effect amenable to the clinical application of objective 3 (below). The project radically renews the field's methodologies because, by using photo-realistic feedback of face and voice, we eliminate all of the experimental demand effects that have plagued previous studies (Strack, Martin, and Stepper, 1988) and because, by controlling both facial and vocal emotional expressions algorithmically, we achieve unprecedented levels of research reproducibility (Wagenmakers et al, in press). The most important risk with this objective is that the effect size of the intervention is found too small for a clinical application; this will be addressed by changing the primary outcomes of the clinical study, aiming to identify markers of symptom severity rather than a full-remediation of the disorder (see Myers et al, 2016 for a recent example).

3. **Non-pharmaceutical remediation of emotional numbing for post-traumatic stress disorders (PTSD):** The project's clinical arm is original because it does not target the primary symptoms of PTSD (*the persistent, involuntary re-experiencing of the event* and *excessive avoidance of stimuli associated with the trauma*), but rather the associated symptom of emotional numbing (*loss of interest for previously pleasurable activities* – APA, 2013). This is relevant to the psychopathology of PTSD because remediating emotional numbing (or alexithymia) will improve patients' emotional awareness, and thus facilitate their regulation of the more problematic traumatic memories associated with the disorder (Gross & Jazieri, 2014). To do so, we will conduct a 3-month longitudinal study in which increased positive feedback from the mirror is used to recondition once-pleasurable, now-bland daily experiences (e.g. going to the movies the day before), and to test the primary outcome of a more positive orientation of the patient towards the experience. The most important risk with this objective is difficulties to recruit patients in the study (delay, drop-outs, etc.); it can be addressed by running a similar study on a sub-clinical sample with alexithymia traits.

II. Organisation du projet et moyens mis en œuvre

Catherine Soladié will coordinate this proposal. Before being Associate Professor at **CentraleSupélec** in FAST team, she was project manager for 5 years at Cap Gemini. She will use in this project her organizational talents and skills in emotions analysis and synthesis. She was part of one of the two Immemo project teams (ANR project coordinated by FAST) who won the first two places in the international challenge AVEC 2012 in emotion analysis. This same Immemo project won the first place in the International Challenge FERA 2011 on micro expressions detection. The FAST team will be responsible for real-time face synthesizing on the mirror.

STMS (UMR9912, CNRS/IRCAM/UPMC) is the country's only laboratory fully devoted to the science and technologies of music and sound. It brings to the project high expertise in emotional speech transformation technologies and in the cognitive psychology of emotional feedback. Jean-Julien Aucouturier (neuroscientist, chargé de recherche CNRS, PI ERC StG CREAM) and Marco Liuni (computer-scientist, chargé de recherche IRCAM) will coordinate STMS participation in the project.

Cognac G (UMR 8257, CNRS/Paris-Descartes/Service de Santé des Armées) works with ecological pervasive environments (e.g. flats, cockpits), smart sensors and applied mathematical tools, in order to measure normal and abnormal human behavior. Cognac G will bring its clinical expertise and infrastructure to the project, notably its capacity to recruit civil and militarian patients for longitudinal studies and access to the 'smart flat' platform at Ecole du Val de Grace (Paris) and Percy military Hospital (Clamart), where the studies will be conducted. Stéphane Buffat (Médecin en chef IRBA) will coordinate the Cognac-G participation in the project.

HumanEvo, specialist in cognitive behavioral, works on human mechanisms understanding in business and individuals adaptability for sustainably change in their environment. Human Evo collaborates with the National School of Police and is very interested in the problem of PTSD.

Dynamixyz is the leader in performance capture market which consists in analyzing the expressions of an actor to transfer them to a 3D character for film and AAA video games. This SMEs will be in charge of detecting a hundred points in 3D on the user's face from multiple cameras behind the half mirror for FAST analysis needs.

The BWB Team (Biology and Women's Beauty) of **Chanel** works on the perception of aging, attraction and health returned by the face related to both genetic and psychological factors. Specifically, the unit Faces Perception, specialist in cognitive psychology, studies the self-perception, self-esteem and perception of health. This partner will develop a half mirror provided with several cameras and LED panels to analyze and re-synthesize the face of the person.

The grant request (about 660K€ for a period of 42 months) will allow IRCAM (170K€) and CentraleSupélec (160K€) each to hire a PhD student in the project and to participate to international conferences. Dynamixyz (138K€) will dedicate an R&D engineer and HumanEvo (104K€) will spend time to monitor people during the test phase. Chanel (37K€) will adapt a mirror design in order to supply it to the project and finally Cognac G (51K€) will make available the SmartFlat with the associated service.

III.   Impact and benefits of the project

The **scientific impact** of the project is two-fold: first, by producing the first multimodal model of audiovisual deformation, it will provide an algorithmic plateform to investigate what time constraints are involved in sychronous vocal and facial feedback – a question important to the field of multimodal interfaces and virtual/augmented reality, notably in time- and performance-critical applications such as those investigated at IRBA. Second, by also opening up the mirror's software tool to the cognitive psychological scientific community, we will provide a reproducible experimental platform to foster collective progress on the much-debated theory of emotional feedback.

The **societal impact** of the project stems, first, from its focus on PTSD, which is a growing concern in modern western societies with e.g. the post-deployment health of army personal as well as civil survivors of unpredictable terror attacks (see e.g. Dantchev et al, 2016 about November 13, 2015 in Paris). Second, the health technology developed in the project will find applications beyond PTSD, for preventive (e.g., a daily, emotional reinforcement of positive experiences) or remediative mental health paradigms (e.g., treatment of anhedonia in major depressive disorders), and as a help module for real-time communication in couple/family therapy.

The project is part of the 12th axis of challenge 4 (health technologies) for several reasons: it is a project that could be part of other challenges (axis 8 of challenge 8 concerning public health) but it strongly implies patients and will lead to an industrial transfer given its high potential for innovation both in technological terms and in terms of use.

Valorization

Academic will publish their results in international journals and conferences in order to confirm their position in the field of emotions analysis and synthesis. The results of this work will lead to a technological transfer. The FAST team CentraleSupélec, currently co-founder of three startups (Dynamixyz, 3D Sound Labs and ImmersiveTherapy) plans to create a startup in collaboration with CognacG on the results of the project if they are positive.