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# When faces "feel" familiar: The role of affective signals in face recognition

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

# WHEN FACES "FEEL" FAMILIAR: THE ROLE OF AFFECTIVE SIGNALS IN FACE RECOGNITION

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by

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## Abstract

Previous research has suggested that there may be an increase in positive affect and autonomic arousal in response to seeing a familiar face. These studies rarely distinguish between faces for which there is only a "feeling" of familiarity, and faces for which this feeling is accompanied by the retrieval of semantic knowledge about the individual. In the current study we aimed to make that distinction. Participants made recognition judgments on famous and non-famous faces while galvanic skin responses (GSR), zygomatic muscle activity, and heart rate (HR) were recorded. We found increases in GSR (autonomic arousal), and zygomatic muscle activity (positive affect) for faces that were accompanied by semantic-access. These results suggest that the positive affective signal may be generated as a result of retrieving semantic information about a face, rather than as a result of some other mechanism, such as processing fluency.

Keywords

Face recognition, familiarity, affect, galvanic skin responses, electromyography, heart rate

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## Table of Contents

## List of Figures

## 1. General Introduction

Faces are some of the most informative and complex stimuli that we encounter on a daily basis. A glance at a stranger's face can provide basic information such as a person's age, gender, and health, but can also provide insight into mood, state of mind, or intentions. We may behave differently depending on the information that we gather from a quick glance at a face. This ability is made more remarkable by the fact that faces are so similar to one another. All faces have the same basic features: two eyes, a nose, and a mouth, arranged in broadly the same configuration. Despite these similarities, we are very efficient at scanning these stimuli and extracting critical information about them. In particular, we are able to recognize a face as belonging to a particular person. We are able to do this in different settings, under different lighting conditions, and from different angles. Even when we are unable to recall any other information about the person, we may still be able to recognize that face as familiar. It is this distinction between "familiarity-only" and "familiarity with semantic retrieval" experiences that will be examined in more detail in the current study.

## 2. Basics of Face Recognition

In cognitive psychology, recognition memory is often described in terms of a dual process model that distinguishes between familiarity and recollection (Yonelinas, 2002). "Recollection" is considered a process that leads to a situation in which the participant can not only recognize a specific item, but also recall the context in which the item was originally encountered. In contrast, “familiarity” is a state in which the item is recalled, but the context is not. The participant knows the item has been encountered before, but she is unable to recall the context in which she saw it. This model can be used to understand face recognition in the classic study-test paradigm. This usually involves a single stimulus exposure, and is often conducted with unknown faces. As such, it fails to adequately describe the type of familiarity that accumulates over many encounters over time, as is typically the case in face recognition in daily life.

It is possible for person recognition to occur without retrieval of the context in which a person was last or ever encountered. Was it in a particular movie? On a talk-show? The cover of a magazine? Once a person has been fully recognized, the specific details of where they were last encountered are less important. Although the context was not retrieved, recognition of the person was completed. One aspect of familiarity in terms of person recognition may pertain to the degree to which semantic information about the person can be retrieved. To fully recognize a person, it is necessary to retrieve at least some semantic information about the individual. This might include the person’s name, her occupation, or any other reason why she could be known. It can even occur without any episodic recollection of a specific encounter. However, it is also possible to recognize people as familiar, without identifying them. In these cases, recognition may simply be based on a feeling of familiarity that is devoid of pertinent semantic information. This feeling can often be quite strong, as in the Butcher-on-the-Bus Phenomenon, when an individual who is strongly associated with a particular context (such as a butcher in a butcher shop) is encountered in a new environment (such as on a bus; Mandler, 1980).

### 2.1. Cognitive Models

There exist many cognitive models of face recognition (Bruce & Young, 1986; Burton, Bruce & Johnston, 1990), but most classic models can be broken down into three major components: The processes that encode the visual structure of the face, those that contain person information, and finally those that contain the emotional significance associated with the individuals.

Structural encoding is the process by which the relationships and dimensions between the facial features are extracted, and a view-invariant representation of the person's face is created. This representation is unique to a particular identity, and is called a Facial Recognition Unit (FRU; Bruce & Young, 1986). When a face is encountered, it goes through this structural encoding process, and is compared against all stored FRUs. If the face matches one of the FRUs, then we decide that the face is familiar.

While this is a critical first step in facial recognition, we know far more information about an individual than simply the structure of their face. We also have biographical information, episodic memories of the person, as well as knowledge about their mental states, attitudes, and personal traits. All of this information is contained in Person Identity Nodes (PINs; Bruce & Young, 1986).  A person's name is generally not included in the PIN, but is given its own stage in the process. It lies outside the PIN because it is often the weakest stage in the process, and can be the point at which recognition fails. All of the above person information can be retrieved, with the exception of the person's name. Such a state has been likened to the Tip of the Tongue (TOT) phenomenon (Brown & McNeill, 1966).

More recent models have grown to include a separate emotional or affective component of facial recognition (Breen, Caine, & Coltheart, 2000; Ellis & Lewis, 2001; Gobbini & Haxby, 2007). Only on rare occasions is a person recognized without any sort of accompanying emotional response. Whether it is as slight as a sense of relief at seeing a familiar face in a crowd, or as intense as encountering an enemy, there is almost always some kind of emotional information attached.

## 2.2 Neural Mechanisms of Face Recognition

Based on the three central components common to most models of face recognition, Gobbini and Haxby (2007) have updated and extended the classic cognitive models to link them to possible neural mechanisms. In their model, the visual and structural components of the face are thought to be processed in what is called the Core System. The occipital face area in the inferior occipital gyrus and the fusiform face area (FFA) in the ventral visual pathway code for the static aspects of the face that allow for individuation and identification, while the superior temporal sulcus represents the more dynamic aspects of faces, such as the interpretation of the shape of the mouth as a smile or expression of disgust.

Gobbini and Haxby attribute person information to what they call the Extended System. This is no longer visual information, but a collection of knowledge about the person. Biographical information is represented in the anterior temporal cortex, episodic memories about the person in the precuneus and posterior cingulate cortex (and likely the hippocampus, although it is not specified in this model), and knowledge about their traits, attitudes, intentions, and mental states in the anterior paracingulate, posterior superior temporal sulcus, and temporoparietal junction.

Finally, the Emotion component is primarily represented in the amygdala. Activity in the amygdala tends to decrease as familiarity and emotional bonding with a face increases (Gobbini, Leibenluft, Santiago, & Haxby, 2004), possibly indicating a role in threat monitoring or vigilance. Interestingly, mothers exhibit increased amygdala activity in response to photos of their own children compared to children with whom they are merely familiar (Leibenluft, Gobbini, Harrison, & Haxby, 2004). As it is unlikely that the mothers view their children as threatening, the authors suggest that the increased amygdala activity may be related to a natural feeling of vigilance and protectiveness over their own children, as compared with children with whom they are merely familiar.

## 3. The Role of Affect in Face Recognition

As alluded to above, there appears to be an emotional or affective component of face recognition. Familiarity is more than just a strictly cognitive experience, it is a physical feeling. These feelings of familiarity have been extensively studied, traditionally using galvanic skin responses (GSR). GSRs are measurements of the changes in the level of conductance on the skin. They are peripheral indices of changes in sympathetic nervous system activity, and are widely considered to reflect autonomic arousal (Critchley, 2002). In 1985, Tranel, Fowles, and Damasio demonstrated that in healthy individuals, viewing of famous faces evokes a larger GSR than viewing of non-famous faces. This suggests that there is an increase in autonomic arousal that may be related to experienced familiarity. Interestingly, this differential GSR effect is only found for famous faces, not famous names (Ellis, Quayle & Young, 1999). This may be unsurprising given that they are fundamentally quite different. Faces are perceptual cues that are intrinsic to the individual with whom we interact, while names represent distinct lexical features.

Neuropsychological work expanded these GSR findings in studies of prosopagnosia, a disorder of face processing. There are two types of prosopagnosia, apperceptive, and associative (Farah, 1991). Apperceptive prosopagnosia is an impairment of face perception. Individuals with apperceptive prosopagnosia tend to describe faces as being grossly distorted. Associative prosopagnosia is an impairment of face recognition. Individuals with associative prosopagnosia can perceive stimuli normally as faces, but are unable to recognize faces that they have encountered previously as familiar or identify them. It is this second type of prosopagnosia that allows us to make inferences about familiarity for faces. In a landmark experiment, Tranel and Damasio (1985) presented two associative prosopagnosics with photos of unknown, famous, and personally-familiar faces, while recording GSR data. They demonstrated that although the patients were behaviourally unable to identify familiar faces, they showed increased GSRs to familiar compared to unfamiliar faces. This illustrated that despite their lack of overt awareness of having encountered the faces before, there was lingering covert evidence of the familiarity.

Capgras syndrome, on the other hand, is often described as the mirror opposite of prosopagnosia. Patients suffering with from this disorder are able to recognize the face of someone that they know, but they lack a feeling of familiarity (Capgras & Reboul-Lechaux, 1923). They often begin to strongly believe that their loved ones have been replaced by an impostor or a double. This delusion tends to be strongest for faces that would be very familiar (i.e.  a spouse, parent, or child) and weaker for faces that should only be moderately familiar (i.e. celebrities). This gradient may be caused by the expectation of a strong emotional response to highly familiar people that people build over a lifetime of experience. The characteristic delusions of Capgras syndrome may arise when that expectation is violated (Breen, Caine, & Coltheart, 2000).

If Capgras is indeed a mirror syndrome of prosopagnosia, one might expect that while overt face recognition would be intact, these patients would fail to show the classic differential GSR activity for familiar compared to unfamiliar faces. Two studies have investigated this question, providing results that converge on similar conclusions. Hirstein and Ramachandran (1997) documented a case study of a thirty year-old man suffering from Capgras delusion following a car accident. His delusions were so severe that, when viewing his own reflection in a mirror, he began to believe that he himself was an imposter. During three separate testing sessions, he was presented with unfamiliar, famous-familiar, and personally-familiar faces. During none of these tests did he demonstrate increased GSR responding for familiar compared to non-familiar faces. Ellis, Young, Quayle, and de Pauw (1997) used the same experimental design to compare GSRs for five Capgras patients, five healthy controls, and five psychiatric controls (patients who were taking similar anti-psychotic medications to that of the Capgras group). While the two control groups both showed increased responding for famous compared to non-famous faces, the Capgras group did not.

Taken together, investigations into these two disorders clearly demonstrate that there are at least two routes to facial recognition. One is an overt, cognitive component, while the other is covert and possibly affective in nature.

### 3.1 Valence of the Familiarity Signal

While GSR provides key evidence for the existence of an autonomic arousal component of face familiarity, the nature of the GSR is such that only limited inferences can be drawn from it (Bradley, 2000). It is considered to be a relatively nonspecific signal that can be elicited many different ways. A loud noise in the environment will evoke it through a startle response. It can be a general orienting response, or an allocation of cognitive and attentional resources toward a stimulus. It can also be triggered by a sharp breath, or movement of any kind. This means, among other things, that the valence of the corresponding feeling of familiarity signal (i.e., whether it is experienced as negative or positive affect) remains unknown. However, studies on the mere-exposure effect and the beauty-in-averageness effect suggest that in the context of recognition memory, the signal may be positive.

The mere-exposure effect is the finding that simply exposing a participant to a particular stimulus several times is enough to increase that person's expression of liking for that stimulus (Zajonc, 1968). Put another way, all other things being equal, as a stimulus becomes more familiar, we tend to like it more. This finding has intuitive appeal given that, in general, familiarity can signal predictability and safety. For example, it can be disconcerting to be in a completely new environment, and seeing a familiar face in a crowd can provide a sense of comfort and relief. This effect suggests that familiarity may be associated with increased feelings of positive affect, a hypothesis that was tested by Harmon-Jones and Allen (2001). They presented participants with unknown faces, or faces that had been previously viewed five times. During the experiment, the participant's positive affect was measured with facial electromyography (EMG) over the zygomatic muscle (a key muscle involved in smiling). The more familiar faces were not only rated as more likeable, but they were also associated with increased zygomatic activity.

Converging evidence comes from the link between familiarity and attractiveness. For example, in a study by Fernandez (2011), it was found that new faces that were incorrectly believed to be familiar were considered more attractive than new faces that were correctly labeled as unfamiliar. The author suggested that, in the absence of semantic information about the face, participants may be using attractiveness as a heuristic to judge familiarity. A more parsimonious explanation for this finding would be processing fluency.

Processing fluency is the ease and speed with which a stimulus is processed. Several factors can contribute to the fluency of a stimulus. Physically, the clarity of a stimulus, the size, or the exposure duration can impact fluency. Additionally, the more often a stimulus is encountered (increasing familiarity), the more fluent it becomes. Winkielman and Cacioppo (2001) suggest that fluently processing a stimulus induces a feeling of positive affect, as measured by zygomatic electromyography (EMG). In short, people tend to feel good when they are able to process a stimulus quickly and easily, and less so when it is difficult.

A well-established finding in the attractiveness literature is that the faces we consider to be most attractive tend to be the ones that look the most average. If several faces are combined using a computer program, the new morphed face is generally considered to be more attractive than any of the component faces (Langlois & Roggman, 1990). A more recent finding is that this effect is dependent on the familiarity of the constituent faces. Halberstadt et al. (2013) found that when the individual faces were themselves highly familiar (i.e. George W. Bush and Barack Obama), the resulting combination was rated as less attractive. But when the individual faces were famous in another country (and therefore not familiar to American participants), the resulting combination was rated as more attractive. Processing fluency explains this result, when comparing the fluency of the individual faces to the fluency of the morph. Famous faces are themselves highly familiar and therefore highly fluent. When they are combined into a new face, the result is less fluent than either of the constituent faces. Thus, this decrease in fluency expresses itself as a lower attractiveness rating. However, when unfamiliar faces are combined, the resulting face is more attractive than its constituent parts, due to the beauty in averageness effect.

## 4. Limitations of Current Literature

While previous work has indicated that there exists an affective familiarity signal, many unanswered questions remain. Since previous studies have not made a distinction between familiarity-only experiences and those accompanied by the retrieval of semantic information about the individual, it is impossible to know whether the change in affect is occurring as a direct result of familiarity, or whether it is generated as a result of semantic-access. There may even be a change in positive affect as a result of achieving a goal (performing well on the experimental task), as has previously been demonstrated (Kreibig, Gendolla, & Scherer, 2010)

Additionally, while psychophysiological measures are informative and easy to record, any one measure in isolation cannot provide a complete understanding of a phenomenon. In the case of the GSR, as previously stated, it can be notoriously difficult to interpret it in relation to a specific cognitive process. When the experimental conditions are carefully planned and tightly controlled, it can be the marker of an emotional response. However, both positive and negative emotions can elicit a GSR. In order to obtain information about emotional valence, additional measures such as facial electromyography (EMG) and heart rate (HR) are required.

Facial EMG indexes changes in affect by recording the activity of key muscles involved in facial expression. Two of the most common are the zygomatic muscle (involved in smiling) and the corrugator muscle (involved in frowning). Zygomatic activity is associated with states of positive affect, and corrugator activity is associated with states of negative affect (Bradley, 2000).

Changes in heart rate reflect another marker of both stimulus intensity and valence. A typical HR response is triphasic, with an initial deceleration, a subsequent acceleration, and final deceleration. Negative images are associated with a larger initial deceleration, while positive images are associated with a larger acceleration (Bradley, 2000).

In order to gain the most comprehensive understanding of any experience of emotional arousal, it is critical to combine as many of these measures as possible. To date, very few (if any) studies have integrated multiple psychophysiology measures in a study of face recognition.

**5. Current Study**

The goal of the current study is to further the understanding of the role of affect in familiarity for faces. Previous work has shown that in healthy individuals, there is an autonomic arousal signal that can be measured in response to familiar faces (Tranel & Damasio, 1985). Investigations into patient populations, the mere-exposure effect and facial attractiveness have indicated that this signal might be positive in nature. I intend to determine whether this affective familiarity signal is generated during familiarity-only experiences, familiarity experiences with semantic access, or both. These questions will be addressed behaviourally with a task designed to separate familiar faces into those accompanied only by a feeling of familiarity, and those accompanied both by a feeling of familiarity and an ability to recall semantic information about the face. The faces employed in this task will be drawn from sets of moderately famous and non-famous faces. This will ensure that any familiarity with the faces is based on overall lifetime experience, rather than exposure in an experimental setting. In order to assess autonomic arousal and emotional valence, galvanic skin responses, facial electromyography, and heart rate will be all measured during the same testing session.

I expect that if the affective familiarity signal is generated as a result of processing fluency, then autonomic arousal and positive affect should both increase in a linear fashion. Unfamiliar faces should be associated with the lowest level of arousal and positivity, semantically-identified faces with the highest level, and familiar faces falling somewhere in-between. By integrating these three psychophysiological measures and using them in conjunction with a behavioural task designed to examine familiarity on a more fine-grained level, I hope to gain a more complete understanding of facial recognition in general.

## 6. Method

### 6.1 Participants

Thirty-seven healthy adults (10 male, 27 female) completed the experimental task (*M* = 22.12 years; *SEM* = 0.48). Prior to participating in the study, each subject gave written informed consent. This study received approval from the Research Ethics Board at the University of Western Ontario. Participants received $30 compensation for their participation in the study. All thirty-seven participants were included in the behavioural analyses, however, for appropriate psychophysiological analysis we required at least ten trials in each condition. A total of nine subjects were excluded from all psychophysiological analyses on this basis. Additional participants were excluded from the analysis for each measure based on poor psychophysiological data. Participants who were excluded from the analysis of one psychophysiological measure were not necessarily excluded from the others.

### 6.2 Materials

The stimuli in this study consisted of one set of 88 faces of famous individuals, and a second matched set of 88 faces of non-famous individuals. The famous faces were drawn from one or more of the following categories: actors (film and/or TV), athletes, musicians, and television personalities/hosts, and were selected through Google Images (www.google.com/imghp). For each face of a famous person, a face of a non-famous person was selected that closely matched the famous face image in terms of gender, approximate age, and general appearance.

The final sets of faces were chosen based on extensive behavioural pilot testing to ensure that the two groups were equated in terms of attractiveness, age, facial expression, and perceived image clarity. All images were 430 x 606 pixels in size, and any differences in average luminance were removed using the SHINE toolbox (Willenbockel et al, 2010).

**6.3 Procedure**

The experimental task consisted of two stages. The first was completed in conjunction with psychophysiological recordings (details below), and involved a familiarity judgment for each face. The second stage required participants to make five additional judgments on each face, as described below. Due to the extended duration of the experiment (the entire task required over two hours to complete), the experiment was conducted in two sessions of approximately one-and-a-half hours each. In each session, participants completed both stages of the experiment using half of each of the famous and non-famous faces. All responses were made using the number pad on a keyboard.

**6.3.1 Stage 1**

While GSR, EMG, and HR were recorded, participants viewed famous and non-famous faces and judged their familiarity (see Figure 1). Each face was presented for 3000 ms, and during that time participants were instructed to indicate whether the face (a) was unfamiliar, (b) looked familiar, but they did not have any semantic information to identify the person, or (c) looked familiar, and they had at least one piece of identifying information about the person. Examples of identifying information would include the person's name, his occupation, or a context in which he had been encountered by the participant. Between trials, participants viewed a fixation cross for 12000-18000 ms. Participants were informed at the beginning of the task that there were an equal number of famous and non-famous faces. Following stage one, all psychophysiological recordings were terminated.

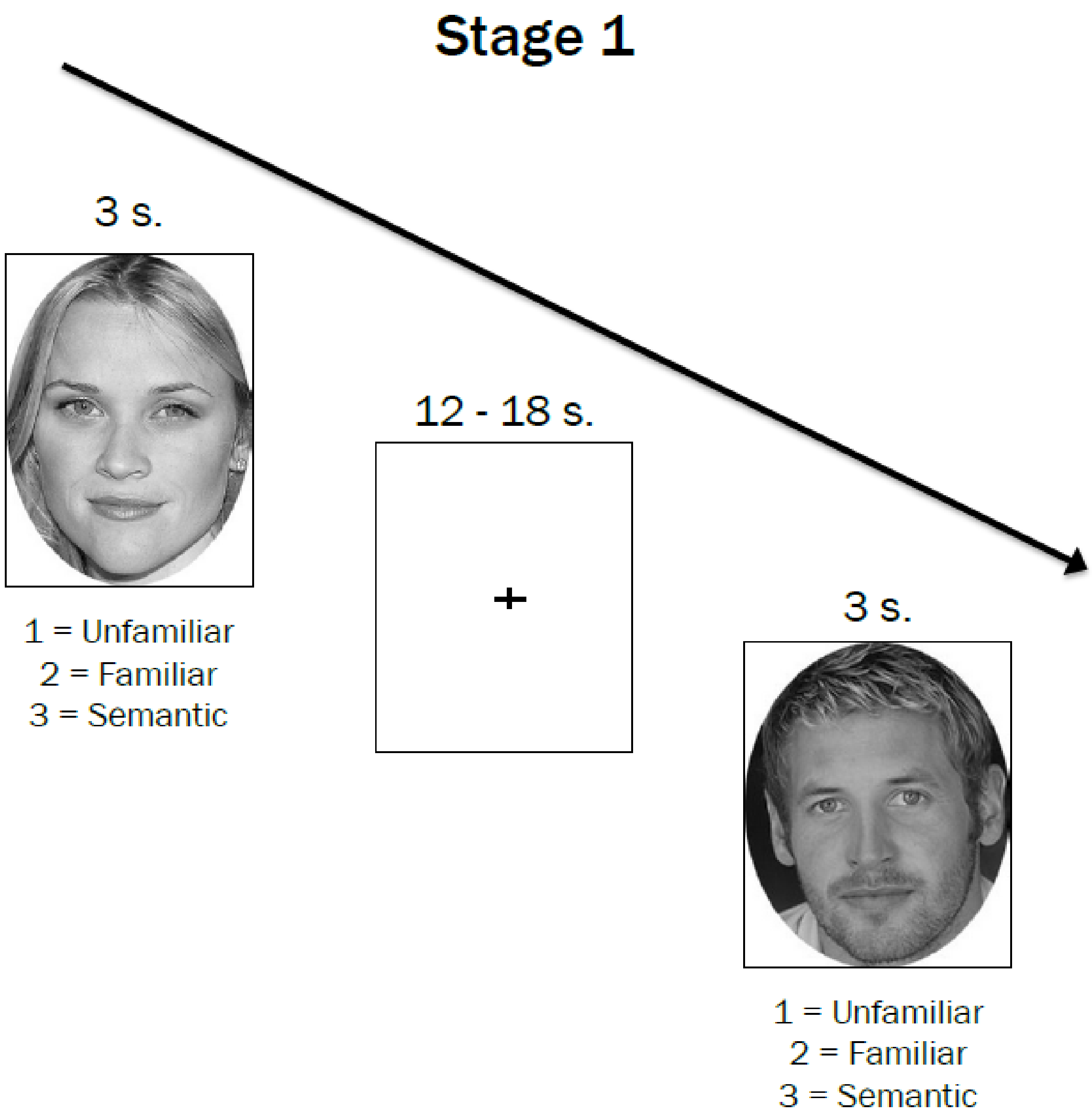


Figure 1. Schematic diagram of stage one of the experimental task.

### 6.3.2 Stage 2

Participants viewed all of the faces that were previously viewed in stage one of the experiment, and made five different judgments on each one in succession (see

Figure 2). For each judgment, the instruction as well as the response options appeared together, below the image of the face. Responses were indicated on a standard keyboard. This stage of the experiment was entirely self-paced. First, was a free-recall period in which participants were instructed to report any identifying information that they could recall about the person whose face they were viewing. Second, participants indicated in a four-alternative forced-choice test whether the person was 1) an actor, 2) an athlete, 3) a musician, or 4) a television personality/host. Participants were instructed to give their best guess even if the face was unfamiliar. Third, participants rated their confidence that the previous occupation judgment was correct. Using a 6-point scale, participants indicated their confidence level, with '6' indicating the highest confidence, and '1' indicating the lowest confidence. Fourth, participants rated the valence of the person's facial expression. This expression judgment used a 7-point scale, with '1' indicating an extremely negative expression (ie. A severe frown), '4' indicating a neutral expression, and '7' indicating an extremely positive expression (ie. A genuine smile). Finally, participants rated the attractiveness of the face. For this judgment "attractiveness" was considered to be the degree to which the participant would want to approach and be with that person. Using a 6-point scale, participants rated the attractiveness of the face, with '1' indicating the lowest level of attractiveness and '6' indicating the highest level of attractiveness . For the purpose of the current study, only the forced-choice occupation judgment and the attractiveness ratings were included in the analyses.

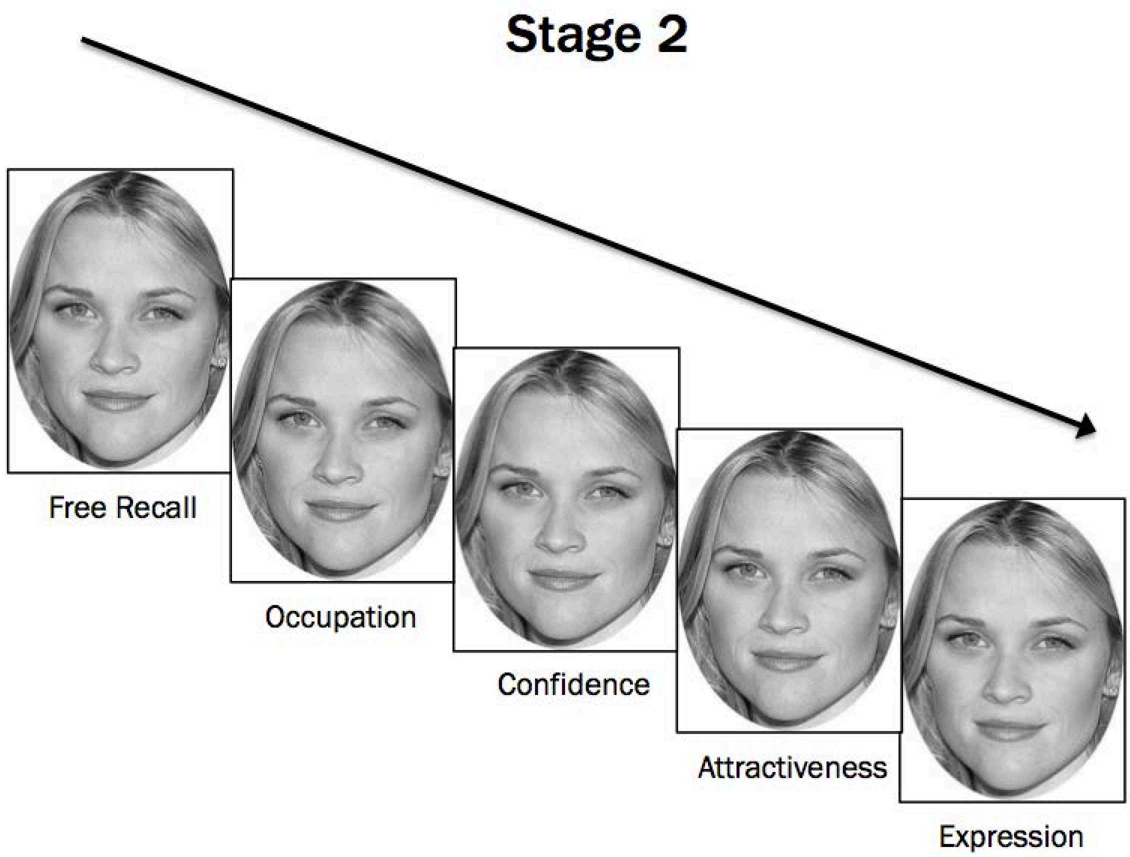


Figure 2. Schematic diagram of stage two of the experimental task.

### 6.4 Psychophysiology Data Acquisition and Preprocessing

All recordings were collected using the BioPac MP150 acquisition system, BioNomadix wireless amplifiers, and a Dell laptop computer running AcqKnowledge software(Version 4.2). All signals were acquired with a sampling rate of 2000 Hz.

#### 6.4.1 Galvanic Skin Responses

GSR data were collected using disposable Ag/AgCl electrodes containing isotonic gel. Electrodes were attached to the pads of the index and middle fingers on the non-dominant hand. Participants were excluded if the GSR signal was non-responsive. This was determined by asking the participants to take several deep breaths, as this is a reliable method of generating a GSR (Johnson, 1961).

Data were analyzed using Ledalab (www.ledalab.de). First, the data were smoothed and any artifacts were identified by eye and removed. Then, the phasic (event-related) component of the signal was decomposed from the tonic (sustained) component (Benedek & Kaernbach, 2010). This procedure allows for the analysis of the GSR signal in relation to a specific stimulus, independent of the overall level of arousal. For each trial, the dependent measure of interest was the Integrated Galvanic Skin Response (IGSR), a measure of phasic GSR activity. This measure was obtained by calculating the area under the curve from 1-6 seconds post stimulus onset. These IGSRs were then standardized within each testing session. Two participants were non-responsive, and were excluded on this basis. A total of 26 participants were included in this analysis.

### 6.4.2 Electromyography

EMG activity from the zygomatic muscle was measured using 8mm Ag/AgCl recording electrodes filled with conductive gel. In order to attain correct placement of the electrodes, the participant was asked to smile and subsequently relax several times. Since the zygomatic muscle is primarily involved in smiling, this allowed the zygomatic muscle to be identified. The raw EMG signal was amplified by a factor of 2000, detrended, and band-pass filtered from 30 - 500 Hz following the guidelines set out by Fridlund and Cacioppo (1986). The resulting filtered data were then rectified and smoothed with 2-Hz low-pass filter. To calculate responses to each stimulus event, the signal was baseline corrected using the 1- sec prior to stimulus onset, and then averaged over each half-second. In order to remove artifacts, trials were discarded if the variability of the signal (relative to each Fame and Response condition) exceeded one standard deviation in the baseline period, 2.5 standard deviations in the period following stimulus onset, or if the total mean variability exceeded 1.5 standard deviations. For the remaining trials, the average change from baseline was calculated for the three seconds following stimulus onset. One participant was excluded from the analysis due to an insufficient number of trials following artifact removal. A total of 27 participants were included in the sample for this analysis.

### 6.4.3 Heart Rate

Heart Rate (HR) was derived from each participant's electrocardiogram (ECG), which was recorded with three disposable Ag/AgCl electrodes filled with conductive gel using a standard lead II configuration. The raw ECG signal was amplified by a factor of 2000. HR data were calculated online using the time interval between consecutive R-R intervals (time between the largest positive deflection in the signal), and then binned into half-second intervals, weighting each HR value by the proportion of each time bin occupied by that value (Graham, 1978). Stimulus related changes in HR were calculated by baseline correcting the HR data using the average of the 2-s prior to stimulus onset. In order to remove artifacts, trials were discarded for the following reasons: 1) At any point there was an abrupt change in

HR that exceeded 15 bpm. 2) During the baseline period there was a change in HR that exceeded 10 bpm. 3) At any point HR was greater than 120 bpm or less than 50 bpm. For each trial, the average change from baseline was calculated from 1-5 seconds post-stimulus onset. Three participants were excluded due to poor psychophysiological data. A total of 25 subjects were included in this analysis.

## 7. Results

### 7.1 Behavioural Results

For stage one, we first compared the proportions of recognition responses for famous compared to non-famous faces (see Figure 3). Paired, one-tailed t-tests revealed that more unfamiliar responses were made for non-famous faces, $t(36) = 12.76$, $p < 0.001$, more familiar responses were made for famous faces, $t(36) = 2.566$, $p = 0.008$, and more semantic-access responses were made for famous faces, $t(36) = 10.32$, $p < 0.001$.

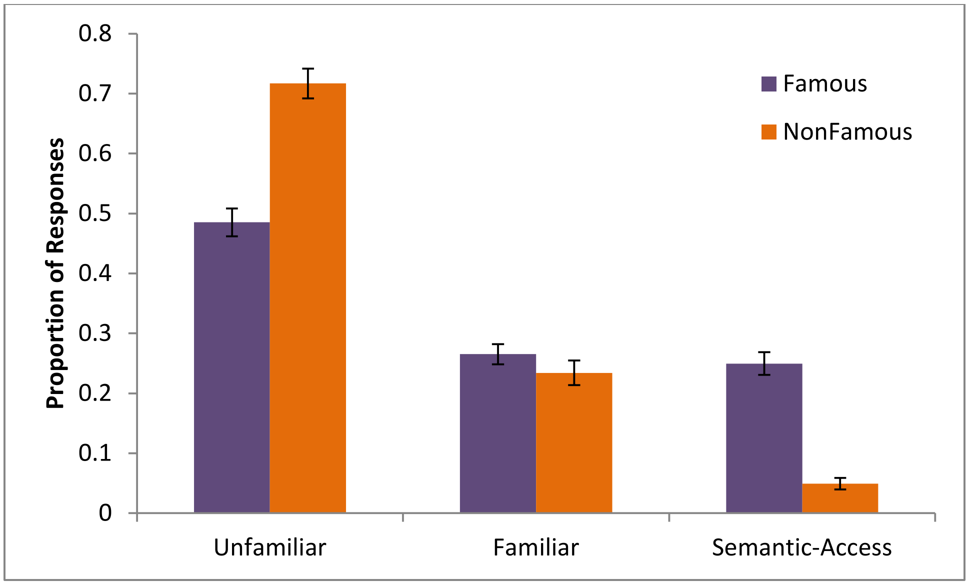


Figure 3. Proportion of recognition responses for famous and non-famous faces. Error bars indicate standard error of the mean, corrected for within-subjects measures.

Next, we compared the average median response time (RT) for each type of recognition-response for famous faces (see Figure 4). A repeated-measures ANOVA revealed that there was a significant difference between the group means, $F$ (2, 36) = 46.43, $p$ < 0.001. Paired, two-tailed t-tests revealed that familiarity-only responses were associated with significantly longer RTs than both semantic-access responses, $t$ = 9.52, $p$ < 0.001, and unfamiliar responses, $t$ = 7.03, $p$ < 0.001.

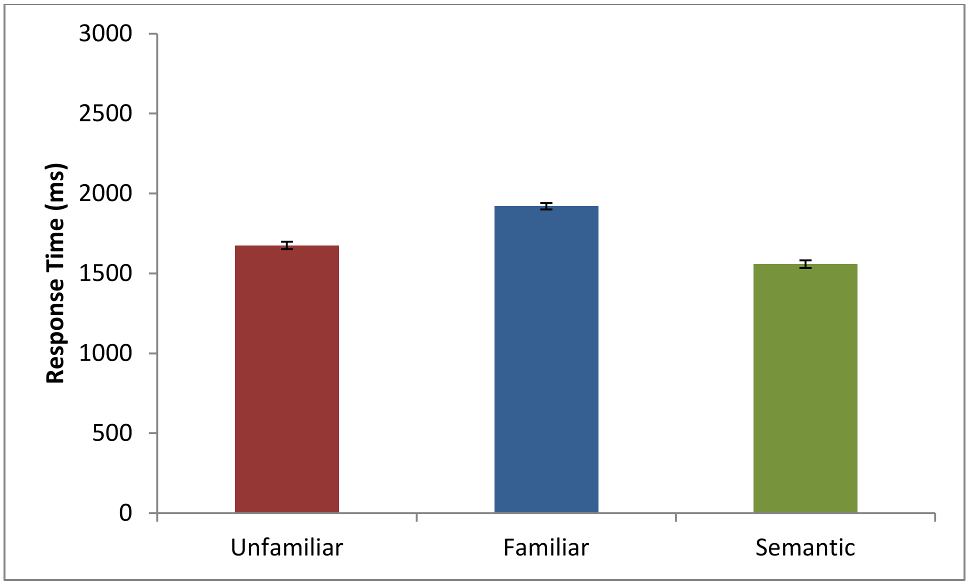


Figure 4. Median response times for each type of recognition response, collapsed over famous and non-famous faces. Error bars indicate standard error of the mean, corrected for within-subjects measures.

In order to confirm the validity of the subjective recognition responses in stage one, we calculated the forced-choice occupation accuracy in stage two for each type of recognition response. Chance rate of performance was calculated by examining the proportions of the four occupations that were correct for each celebrity. For the entire set, the average of these proportions was computed to calculate the chance rate of 0.261. Figure 5 shows the mean accuracy for each level of familiarity. Single sample t-tests were used to determine if accuracy significantly differed from chance. We found above-chance performance for semantic-recall responses, $t(36) = 20.62$, $p < .001$, familiarity-only responses, $t(36) = 6.95$, $p < 0.001$, and unfamiliar responses, $t(36) = 6.97$, $p < 0.001$. Since all familiarity responses were associated with above-chance performance, some semantic knowledge may have been available in each case. A one-way repeated-measures ANOVA revealed a significant difference between group means, $F(2, 36) = 123.14$, $p < 0.001$. Subsequent paired, one-tailed t-tests revealed that participants' accuracy was significantly higher for semantic-recall than for familiarity-only trials, $t(36) = 11.92$, $p < .001$, and accuracy for familiarity-only trials was significantly higher than for unfamiliar trials, $t(36) = 2.16$, $p < 0.05$. This suggests that the subjective recognition responses in stage one are valid with respect to objective measures of semantic-access in stage two.

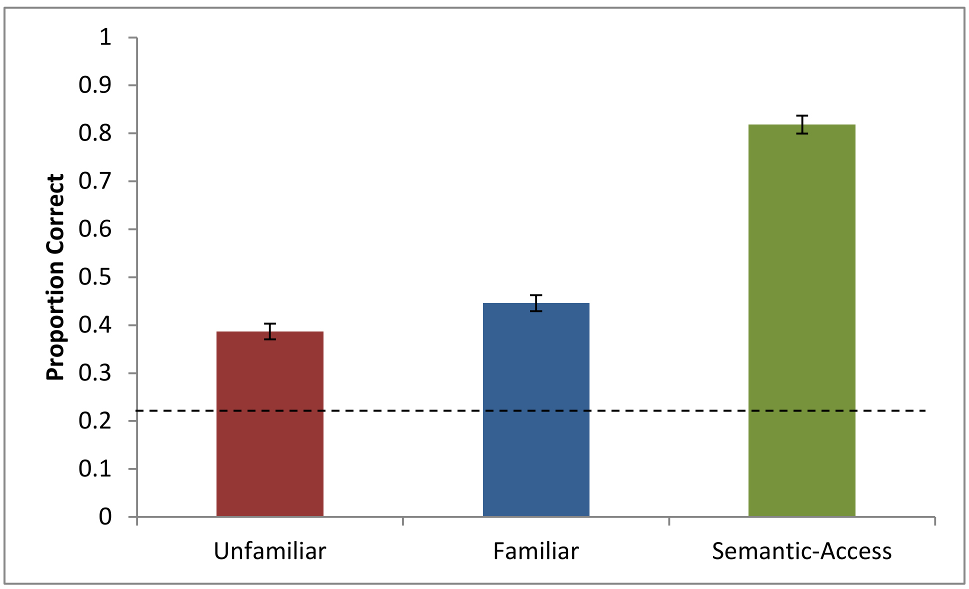


Figure 5. Accuracy on the forced-choice occupation judgment for each type of recognition response, for famous faces. Error bars indicate standard error of the mean, corrected for within-subjects measures. Dashed line indicates chance performance.

Next, we were interested in determining whether more familiar faces would also be considered more attractive (mere-exposure effect). However, before examining the relationship between familiarity and attractiveness, we first used a two-tailed, paired-sample t-test to ensure that the average attractiveness ratings were equal between famous and non-famous faces. We found that there was no significant difference in the ratings between these groups, $t(36) = 0.81$, $p = .43$. Figure 6 shows the average attractiveness ratings associated with each recognition-response, collapsed over famous and non-famous faces. A one-way repeated-measure analysis of variance (ANOVA) revealed that there was a significant difference between the group means, $F\ (2, 36) = 59.36$, $p < 0.001$. Subsequent paired-sample t-tests revealed that faces accompanied by semantic-recall were rated as significantly more attractive than familiarity-only faces, $t(36) = 4.29$, $p < 0.001$, which in turn were rated as significantly more attractive than unfamiliar faces, $t(36) = 9.61$, $p < 0.001$. This indicates that the perceived attractiveness of a face increases with familiarity for that face, which is in agreement with the mere-exposure literature.

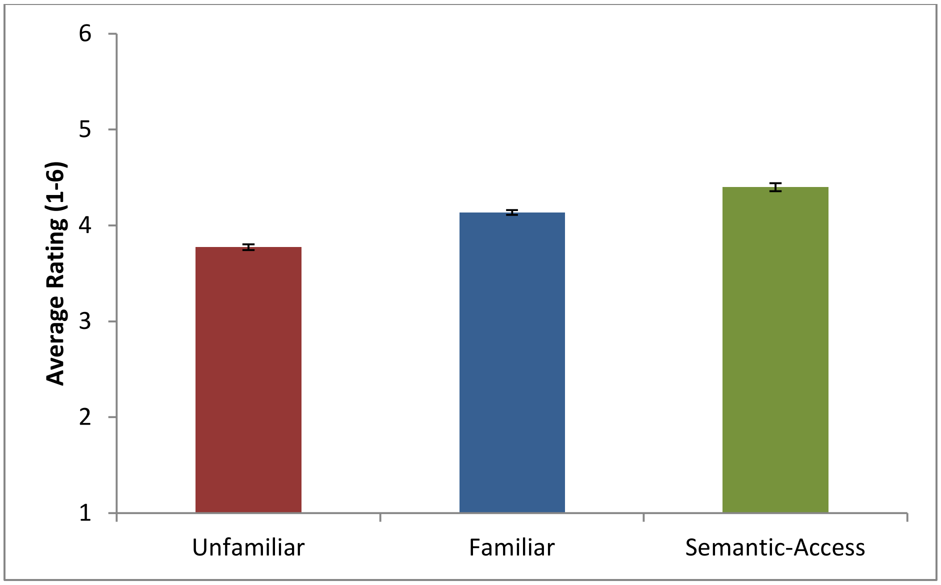


Figure 6. Average attractiveness ratings for each type of recognition response, collapsed over famous and non-famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

### 7.2 Psychophysiology Results

#### 7.2.1 Galvanic Skin Responses

Figure 7 shows the z-transformed integrated galvanic skin response (IGSR) for famous compared to non-famous faces. A paired t-test revealed that famous faces elicited a significantly larger IGSR compared to non-famous faces, $t(25) = 2.63$, $p < 0.05$. Figure 8 shows the z-transformed IGSR for famous faces only, comparing the average IGSR for each type of recognition response. We conducted a repeated-measures ANOVA on these values and discovered that there was a significant difference between mean IGSRs for each type of recognition-response, $F(2, 25) = 4.973$, $p < 0.01$. Pairwise comparisons revealed that semantic-recall responses were associated with significantly larger IGSRs than both familiarity-only responses, $t(25) = 2.98$, $p < 0.05$, and unfamiliar responses, $t(25) = 3.48$, $p < 0.01$. This suggests that semantic-recall responses were accompanied by an increase in autonomic arousal.

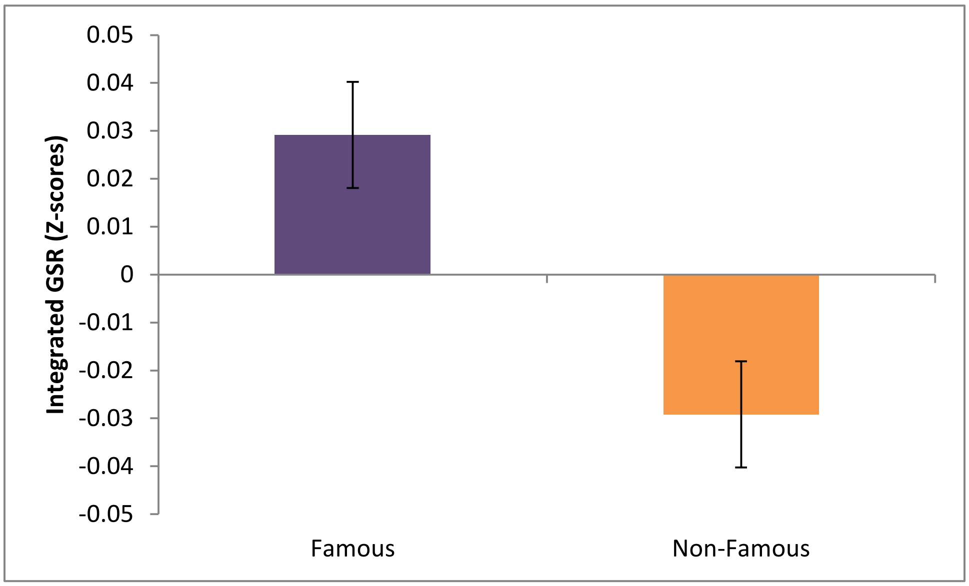


Figure 7. Mean IGSR (z-scores) for famous and non-famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

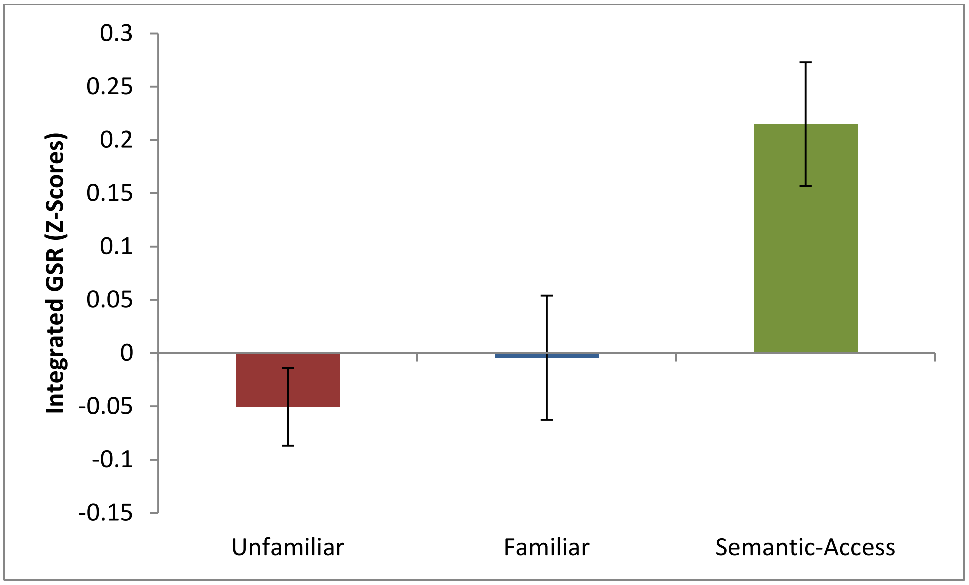


Figure 8. Mean IGSR (z-scores) for each type of recognition response, for famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

### 7.2.2 Electromyography

Figure 9 contrasts the change in EMG from baseline between famous and non-famous faces. For each group, we calculated the mean EMG change in the three seconds post-stimulus onset. A paired-sample t-test indicated that there was no significant difference between famous and non-famous faces, $t(26) = 1.36$, $p = 0.093$. Figure 10 shows the change in EMG for famous faces only, comparing zygomatic activity for each type of familiarity-response. To investigate differences in activity for the different types of recognition responses, we conducted a repeated-measures ANOVA on the mean EMG change during the three seconds that the stimulus was presented and the recognition response was collected. The ANOVA revealed that there were significant differences in the means between response types, $F$ (2, 26) =

5.42, $p < 0.01$. Pairwise comparisons revealed that faces associated with successful semantic access elicited a greater EMG response than both the familiarity-only faces $t(26) = 2.74$, $p < 0.01$, and the unfamiliar faces $t(26) = 2.00$, $p < 0.01$. This indicates that semantic-access responses are accompanied by an increase in positive affect.

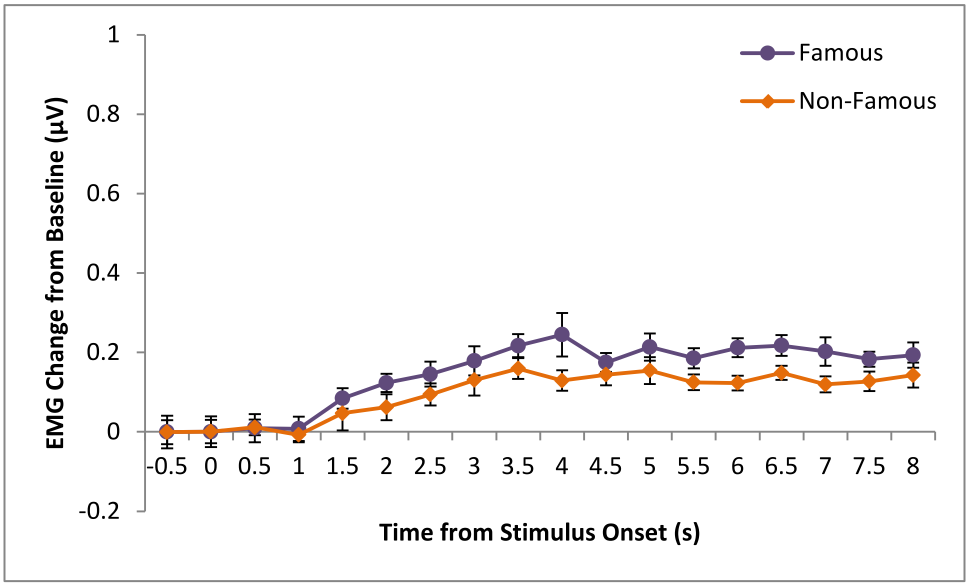


Figure 9. EMG change  from baseline for famous and non-famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

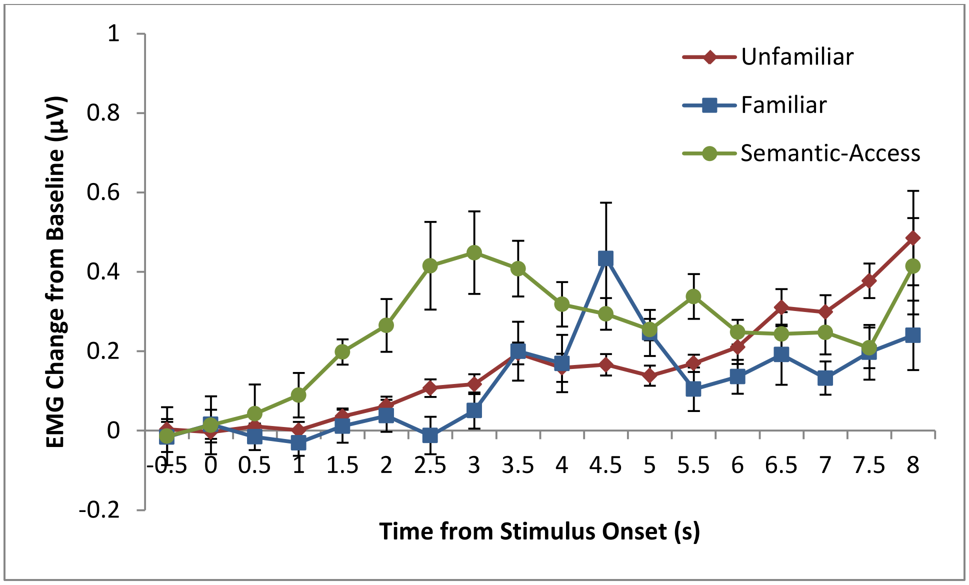


Figure 10. EMG change from baseline for each type of recognition response, for famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

### 7.2.3 Heart Rate

Figure 11 shows the change in heart rate (HR) from baseline for famous compared to non-famous faces. To compare the HR response between the two trial types from one to six seconds post-stimulus onset, we conducted a paired-sample t-test. The t-test indicated that there was a greater HR deceleration for famous faces compared to non-famous faces, $t(24) = 2.07$, $p < 0.05$. Figure 12 illustrates the change in HR for famous faces only, comparing the HR data for each type of familiarity response. A repeated-measures ANOVA indicated that there is no significant difference between the group means, $F(2, 24) = .56$, $p = 0.58$. These findings suggest that famous faces may have elicited a greater orienting response than non-famous faces, but that this orienting response did not differ between recognition-responses.

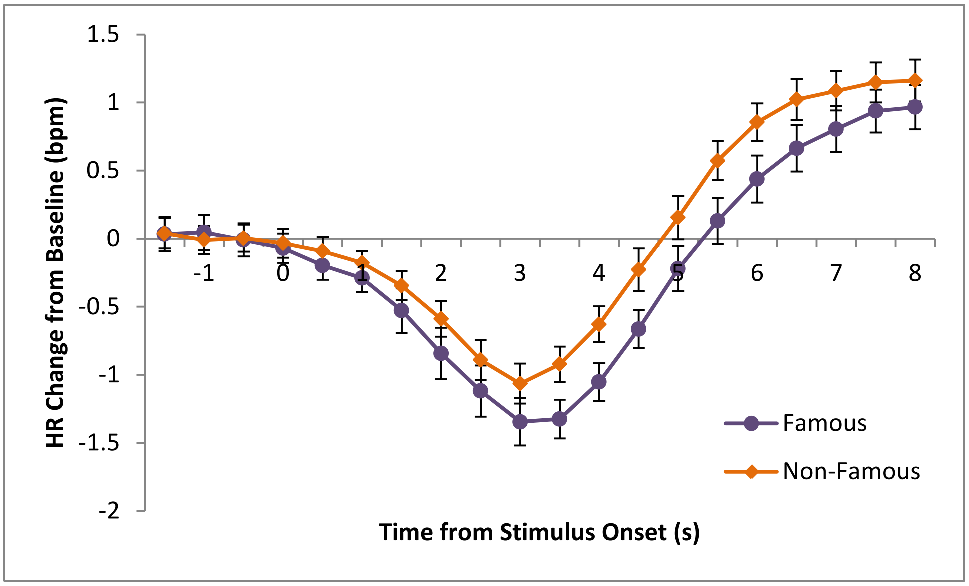


Figure 11. HR change from baseline for famous and non-famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

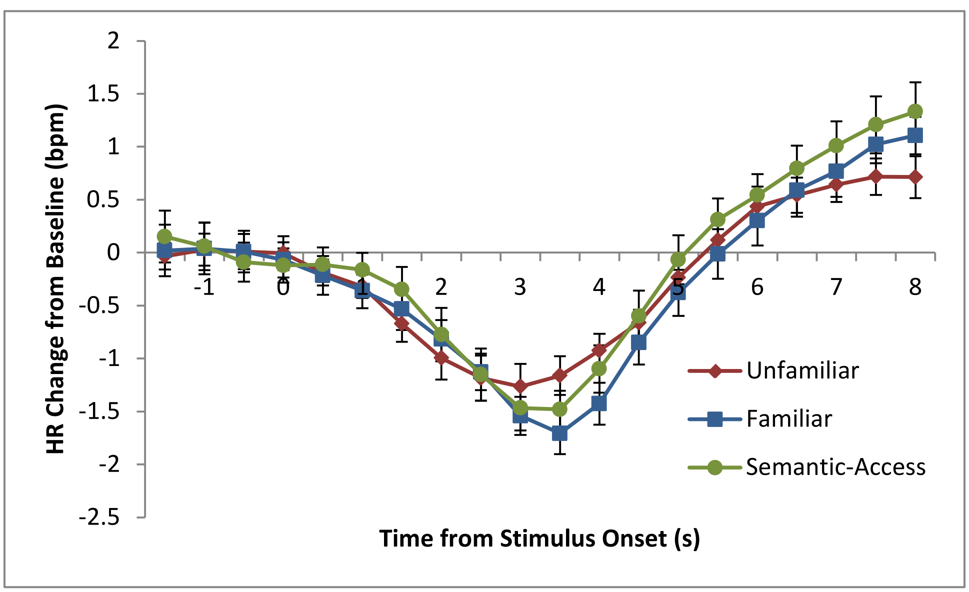

Figure 12. HR change from baseline for each type of recognition response, for famous faces. Error bars indicate the standard error of the mean, corrected for within-subjects measures.

## 8. Discussion

The goal of the current study was to further the understanding of face recognition by investigating the role of affect in the recognition decisions. Specifically, we were interested in determining whether increases in positive affect and autonomic arousal would accompany differing experiences of face recognition. To achieve this goal, we implemented a task that required participants to specify whether a famous or not-famous face was associated with only a feeling of familiarity, or whether it was also accompanied by access to semantic information about the individual. During task execution, we recorded three psychophysiological measures. They included galvanic skin responses in order to assess autonomic arousal, zygomatic muscle activity (via facial electromyography) to index positive affect, and heart rate to investigate both arousal and affect. Finally, following completion of recognition decisions for all faces employed, we collected additional behavioural measures of attractiveness and occupation judgments for the stimuli, independent of any psychophysiological recordings. This allowed us to validate subjective reports of semantic identification with an objective measure, and to compare psychophysiological and behavioural measures of positive affect.

The behavioural results from stage one showed significantly different proportions of responses for famous compared to non-famous faces. Specifically, more unfamiliar responses were made for non-famous faces, and more familiar and semantic-access responses were made for famous faces. For familiar and semantic-access responses, this is important because it indicates that for our subsequent analyses these responses convey a meaningful memory signal. Additionally, response time results indicated that participants were slower to make familiarity-responses compared to semantic-access responses.

The behavioural results from stage two indicated that, on average, famous and non-famous faces did not differ in terms of attractiveness ratings; this is important to establish because it means that any differences in arousal or affect for both stimulus classes cannot be attributed to overall differences in attractiveness. Interestingly, we found that faces that were associated with higher levels of recognition were also considered more attractive. This can be interpreted as evidence for the mere-exposure effect in that increasing familiarity is associated with increased feelings of "liking" or attractiveness.

Additionally, we assessed whether or not participants could truly access any semantic information by asking them to make a forced-choice occupation judgment for each face. Critically, faces that were accompanied by perceived successful semantic identification were associated with higher levels of accuracy on occupation judgments as compared to faces accompanied only by a feeling of familiarity. This finding validated the subjective recognition-responses in stage one, because it showed that increasing levels of recognition were associated with increased level of semantic-access.

Analysis of the psychophysiological data revealed increased autonomic arousal (as measured by galvanic skin responses) and a greater HR deceleration for famous compared to non-famous faces. This served to replicate the classic finding of increased autonomic arousal to famous faces compared to non-famous faces (Tranel, Fowles, & Damasio, 1985). However, our results extended this finding by demonstrating that there was a greater HR deceleration for famous compared to non-famous faces. This result is interesting because while an initial acceleration is usually associated with increased feelings of positivity (Bradley, 2000; Guerra et al., 2012) a greater subsequent deceleration has been linked to an orienting response (Cook & Turpin, 1997). Indeed, previous work has shown that a greater HR deceleration is observed in response to stimuli that are later recalled on a memory task than for those that are later forgotten (Jennings & Hall, 1980; Abercrombie, Chambers, Greischar, & Monticelli, 2008). As such, the HR deceleration in the present study may indicate that famous faces are associated with a greater orienting response than non-famous faces.

In a subsequent analysis we compared the psychophysiological data for each type of recognition-response, for famous faces. This analysis revealed increased autonomic arousal (as measured by galvanic skin responses) and increased positive affect (as measured by zygomatic muscle EMG) in response to faces that were accompanied by semantic-access. No such increase was found familiarity-only faces. This finding could suggest that the increase in autonomic arousal and positive affect that has typically been associated with fame is related to the retrieval of semantic information about the individual, not strictly to the sense of familiarity itself. It might also be related to a feeling of achievement due to high task performance. Participants are aware that they are participating in a memory experiment, and thus being able to identify a face might instill a feeling of success in the participant. Indeed, task success or goal achievement has been associated with increased feelings of positive affect, autonomic arousal, and changes in HR (Kreibig, Gendolla, & Scherer, 2010). Conversely, familiarity-only responses may in effect be a “last resort” for the participant, in that the participant only arrives at that response after eliminating the other two options. In that sense, the participant may associate a “familiarity-only” response with some degree of task failure.

The absence of increased psychophysiological responses for familiarity-only faces is somewhat surprising given the predictions based on processing fluency. Previous work has shown that increased processing fluency is associated with increased positive affect (Winkielman & Cacioppo, 2001). If we assume that faces accompanied by familiarity-only experiences have a higher degree of processing fluency than unfamiliar faces and if the affective signal is generated by processing fluency, then we would predict at least a small increase in arousal and positive affect for familiarity-only trials compared to unfamiliar trials. But since this was not the case, it appears that the affective familiarity signal may not be directly linked to processing fluency as was previously thought. It is interesting to note that while the psychophysiological data do not support a linear increase in arousal and positive affect over the three types of recognition responses, this does not hold true for the attractiveness ratings. Faces that were accompanied by semantic-access received the highest attractiveness ratings, followed by those with experiences of familiarity-only, and unfamiliar faces received the lowest ratings. This can be taken to mean that an increase in positive affect (as measured by attractiveness ratings) was observed for experiences of familiarity-only, although this difference was not detected by the psychophysiological measures. This illustrates the fact that the psychophysiological measures are very complex, and each incorporates more processes than simply "autonomic arousal" or "positive affect".

Despite the current lack of psychophysiological evidence for an affective signal associated with familiarity-only responses, it is possible that it was simply not detected with the behavioural task that was administered and/or the analytical techniques employed to examine psychophysiological responses in the present study. This could occur for a number of reasons. For one, the familiarity signal itself may be highly subjective, and therefore highly susceptible to inter-individual differences. That is, while some participants may be truly able to sense this affective signal and use it as a basis for their familiarity decisions, others may not be so tuned in their own bodily sensations and thus unable to do so. This ability to detect and attend one's own internal state is known as interoception, and is commonly measured using a simple heart-rate variability task (Schandry, 1981). On such a task participants are simply asked to count the number of their own heartbeats that they can detect within a given time interval. Higher accuracy on this task is interpreted as a higher level of interoceptive awareness. Prior research has indicated that higher heartbeat-perception accuracy is associated with higher performance on an intuitive reasoning task (Dunn et al., 2010). In the present study, including a subset of participants with superior interoceptive awareness might facilitate the detection of the affective signal for familiarity-only trials.

Additionally, the structure of the behavioural task itself could explain the absence of a psychophysiological effect for familiarity-only trials. The task used a slow event-related design in order to accommodate the slow nature of the GSR. This not only increased the overall length of the experiment substantially, but it also resulted in a rather dull experience for the participant. A lack of participant engagement can be problematic for any cognitive experiment, but it can have an even larger impact on psychophysiological recordings. In particular, the GSR signal is closely tied to participant engagement. It is also subject to habituation, sometimes within just a few trials (Bradley, 2000).

The pattern of activity found in the HR data is unlike that found in either the EMG or GSR data. While famous faces elicited a greater HR deceleration than non-famous faces, no significant differences could be detected between the different recognition-responses. In terms of comparing famous to non-famous faces, this might reflect a dedication of cognitive resources in the pursuit of determining the identity of the famous face. However, since no significant differences in HR were found at the level of explicit recognition judgments, it may be the case that the orienting response in the HR signal is more of an implicit response.

Alternatively, it is possible that noise in the HR signal prevented the difference between recognition responses from reaching significance. It may be the case that the HR signal is more susceptible to inter-individual differences. However, a visual inspection of the HR signal for each type of recognition response reveals that familiarity-only responses tend to be associated with the largest deceleration, followed by semantic-access responses, and unfamiliar responses with the smallest deceleration. Although these differences did not reach significance, an analysis of the response times lends tentative support to this explanation. Participants were the slowest in making familiarity-only responses, followed by semantic-access responses, and were the quickest in making unfamiliar responses. This supports the idea that familiarity-only responses are the most difficult to make, and elicit a greater orienting response. Semantic-access trials are easier, because although participants must search for semantic information about the face, they do conclude that search at some point, achieving their goal. Unfamiliar trials would likely be the easiest, because in theory, a quick glance with the absence of any feeling of familiarity would be enough to make that response.

## 6.1 Future Directions and Conclusions

An interesting future line of research would be a closer examination of the timing of the affective signal. This would allow us to determine whether the signal informs the participant's familiarity decision, or whether it actually arises as a result of having made the decision itself. In particular, it would be ideal to analyze the psychophysiological data with respect to the time of the recognition response, on a trial-by-trial basis. This would allow further inference into whether the affective signal informs the recognition response, or if it arises as a result of task success. The

GSR and HR profiles take several seconds to develop, which would not be informative in this case. However, the nearly instantaneous nature of the EMG signal makes it ideal to investigate to this end.

Future studies could also make small changes to the paradigm in the hopes of detecting the affective signal for familiarity-only responses. First, including some index of participant interoceptive awareness (such as the heart-rate variability task) would be helpful, since it is possible that not all individuals are able to detect this affective signal. Secondly, converting the experiment to a fast event-related design would shorten the testing session considerably, and would likely increase participant engagement and attention. Using the deconvolution procedure implemented in Ledalab, it is possible to isolate phasic GSR activity even with short interstimulus intervals.

In conclusion the current study found that an affective familiarity signal is found for experiences of familiarity accompanied by semantic-access, but not for experiences of familiarity-only. This finding suggests that the increase in positive affect that has been found for faces and stimuli that are familiar compared to unfamiliar may in fact be more related to the process of accessing semantic information about the individual rather than being generated by increasing levels of familiarity itself. It remains unclear whether the positive affect increases as a direct result of accessing semantic information about the individual (and thereby providing information on which to base a familiarity response) or whether it increases as a result of some degree of satisfaction at performing well on the current task. Future studies should aim to more closely investigate the time-course of this affective response.

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## Curriculum Vitae

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### Education

| | |
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| 2012 – 2014 | Master of Science in Psychology (sub-area Behavioural and Cognitive Neuroscience), University of Western Ontario (London, Ontario). |
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| 2012-2014 | Western Graduate Research Scholarship, University of Western Ontario |
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