Neural Correlates of Familiar Face Versus Person Recognition: Evidence from self-, associative and repetition priming studies

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Milena Maria Bojdo

Neural Correlates of Familiar Face Versus Person Recognition
Evidence from self-, associative and repetition priming studies

Abstract

Recognizing familiar faces is a highly efficient process that involves a hierarchy of representations, consisting of structural, long-term visual and semantic (person-related) information. These are reflected in event-related potential (ERP) components: the N250 is associated with access to domain-specific, long-term visual representations of faces, while the subsequent Sustained Familiarity Effect (SFE) is hypothesised to reflect domain-general stages of familiarity processing. However, the properties of these representations remain poorly understood.

This dissertation used self-, associative- and repetition- priming to investigate whether the SFE reflects perceptual familiarity with a face, access to post-perceptual representations of familiar people, or the prediction of a response to the target (familiar/unfamiliar). Consequently, if the SFE reflects perceptual familiarity, it should increase after repeated face exposure. If it indexes access to domain-general person knowledge, it should be enhanced by relevant associative cues (e.g. names). To test this, personally familiar and unfamiliar faces were preceded by: (1) the name of the same or a different person (self-priming), (2) an associated or unrelated name (associative priming), (3) the same or a different face (repetition priming).

Results showed that the N250 is sensitive to within- and cross-domain priming, indicating an earlier shift towards modality-independent processing than previously assumed. Crucially, the SFE was enhanced by self- and associative priming, suggesting that activating person-specific knowledge can facilitate access to domain-general representations. The detected familiarity effect was additionally influenced by the prediction of an upcoming familiar or unfamiliar target. Together, these findings confirm that the SFE reflects post-perceptual processing of contextual and identity-specific associative cues rather than visual recognition of a face. Importantly, priming revealed that context-based expectations and person knowledge influence familiar face recognition, offering new insight into how we dynamically integrate information in real-world contexts – a process essential for successful interactions that has rarely been addressed by face recognition research.

Neural Correlates of Familiar Face Versus Person Recognition:

Evidence from self-, associative and repetition priming studies

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Masters by Research Dissertation

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Psychology

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2024

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Statement of Copyright

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Chapter 1

General Introduction

1.1. Face Recognition

Recognizing faces of familiar people is typically highly accurate (Young & Burton, 2017). This ability is robust and image-invariant, as we can efficiently identify known individuals from previously unseen or severely degraded photographs, despite significant variations in viewpoint, facial expression, age, lighting conditions, noise and more (Burton, 2013; Burton et al., 2011; Burton et al., 1999; Lander et al., 2001). In daily life, such remarkable skill is essential for successful social interactions.

Consequently, a theoretical perspective common in the study of face recognition assumed that people naturally gain expertise in this ability (Diamond & Carey, 1986; Tanaka, 2001). According to the definition by Young & Burton (2018), being a "face expert" should indicate a highly accurate and relatively automatic (*quick, non-conscious and capacity-free*; Palermo & Rhodes, 2007*)* performance during face recognition-related tasks that is rooted in substantial experience.

In direct contrast to familiar face recognition, this perspective of expert processing does not hold true when considering unfamiliar face recognition. It is a fallible skill which can be challenged even by relatively miniscule changes in face stimuli, including natural within-person variability (reviewed by Burton & Jenkins, 2011). We perform surprisingly poorly when tasked with unfamiliar face matching, which requires participants to determine whether a set of different face images depicts the same person or not (Megreya & Burton, 2006; Megreya & Burton, 2008). Importantly, card sorting tasks require participants to sort a variety of different face photographs into identity piles, one per each identity present in the set. While they perform almost perfectly when sorting familiar faces, participants tend to significantly overestimate the number of unfamiliar identities present in a set if they are not made aware of it beforehand (Andrews et al., 2015; Jenkins et al., 2011). Thus, this shows that people clearly struggle with correctly identifying that two different photos actually show the same person - "telling people together", rather than "telling people apart" - seeing that two photographs depict different people *(*Andrews et al., 2015*).* As such, the assumed expertise seems strongly dependent on the representation of the face we hold, which in turn depends on our degree of familiarity with the individual face (Burton et al., 2011; Jenkins et al., 2011). This importance of familiarity has significant theoretical implications that must be considered to effectively investigate face recognition.

Numerous findings suggest a qualitative difference between how familiar and unfamiliar faces are processed and cognitively represented (reviewed by Johnston & Edmonds, 2009). This includes evidence from neuroscientific research (fMRI findings, e.g. Weibert et al., 2016; Visconti di Oleggio Castello et al., 2017; EEG findings, e.g. Wiese et al., 2019c; Sommer et al., 2021) and from behavioural tasks, such as face matching (e.g. inverted/upright matching; Megreya & Burton, 2006) and detection tasks (Gobbini et al., 2013) performed by typical face recognizers and by individuals with prosopagnosia ("face blindness", Malone et al. 1982; Wegrzyn et al., 2019). These results can be directly related to the seminal cognitive models of face processing (Bruce & Young, 1986; Burton et al., 1990; Burton et al., 1999) which together can guide the subsequent identification and description of the potentially distinct neural underpinnings of familiar and unfamiliar face recognition.

1.2. A Cognitive Model of Face Recognition

The Bruce & Young (1986) model of face processing has been central to establishing the theoretical understanding of familiar and unfamiliar face recognition. It describes a multi-component structure, where a face is serially processed through several stages, relying on the access to different information codes for successful recognition (Schweinberger & Neumann, 2016). This classic architecture inspired numerous research efforts (Schweinberger & Burton, 2011) and has been generally upheld by subsequent models (Haxby et al., 2000; Schweinberger & Burton, 2003). In addition to Bruce & Young's (1986) serial framework, this thesis will specifically acknowledge its expansion by Burton and colleagues (Burton et al., 1990) who described an interactive activation and competition (IAC) structure of face processing (McClelland & Rumelhart, 1981).

Notably, Bruce & Young (1986) distinguish between pictorial and structural codes. Pictorial codes are image-specific representations we generate for the visual instance in which a face is viewed (e.g., a specific photograph). Essentially, a pictorial code is the visual image of a face, as it is seen in a specific moment. A pictorial code of a specific face enables us to recognize this face in the exact same image, or in very similar angle/lightning/expression.

Structural codes can be defined as more abstract and image-invariant representations of a known face. During structural encoding, we visually analyse a face, extracting its key features (e.g., shape, proportions) and transform this information into a representation of that face that is now independent of picture-specific features (e.g., lighting, pose, expression). Familiar face recognition is possible when there is a match between the structural code of the viewed face and its representation stored in our memory – the so-called 'Face Recognition Unit' (FRU; see 1.3). This is followed by a retrieval of identity-specific semantic information attached to the familiar person and name recall (Burton et al., 2011; Freiwald et al., 2016).

As such, this cognitive model provides a convincing explanation for the qualitative difference between familiar and unfamiliar face processing. Researchers propose that unfamiliar face recognition is predominately reliant on pictorial codes, explaining the difficulties with recognizing unknown faces under new visual conditions. In contrast, familiar face recognition is considered primarily dependent on a stored structural representation of an individual's face – a representation that is independent of picture-specific changes in lighting, expression or viewing angle (Burton et al., 2005; Burton et al., 2011; Kramer et al., 2018).

1.3. Face Recognition Units: How do we recognize a face?

Familiar face recognition relies on a robust and abstract representation of a known face that becomes active once the face is viewed from any image ("image-independent") or during social interactions (Burton et al., 2005; Burton et al., 2016). Bruce & Young (1986) identified such stored descriptions as 'Face Recognition Units' (see Figure 1), with a FRU present for each of all known faces.

The IAC architecture proposed by Burton et al. (1990) expanded on the serial framework by Bruce & Young (1986) by incorporating a connectionist framework to explain face and person recognition. It depicts individual processing units organised into pools. Units within each pool are connected via inhibitory links (not depicted on Figure 1), while the links between units from separate groups are excitatory (McNeill & Burton, 2002; Wiese et al., 2017; see Figure 1). The first central pool of units are the image-independent FRUs. A FRU activates once it receives sufficient input from a pictorial representation (i.e. a visual copy) of the perceived face. Other FRUs should be inhibited, allowing us to differentiate between seen faces. This model also acknowledges the domain-specificity of the FRUs, which implies that a unit from this pool can only be directly activated by seeing the familiar face. This organization is mirrored by the pool storing Name Recognition Units (NRUs; Burton et al., 1990; Wiese et al., 2017).

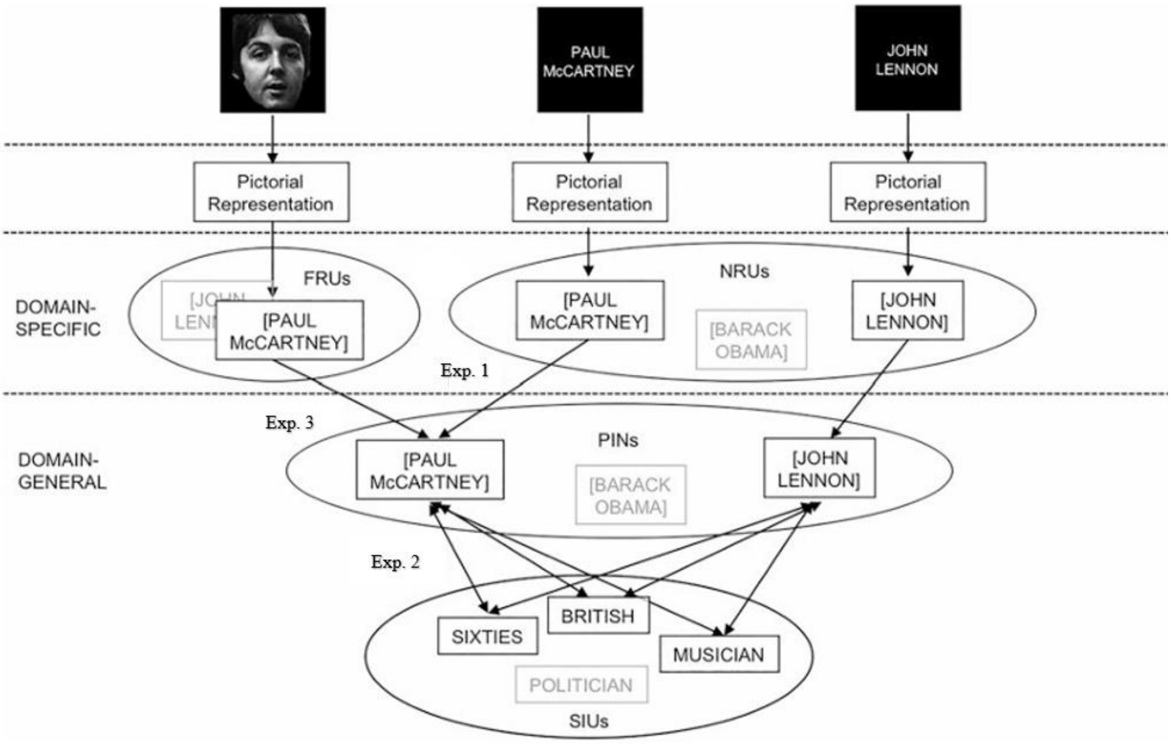

Figure 1. From Wiese et al. (2017): A modified depiction of the interactive activation and competition (IAC) model of face and person recognition by Burton et al. (1990). Note the marked cognitive loci for the activation of domain-specific (Experiment 3) and domain-general (Experiment 1 and 2) representations of familiar faces and people (for more details on each experiment see Chapter 2).

Therefore, an FRU's activity should be facilitated by any relevant input depicting a familiar face (e.g. its picture; Bruce & Young, 1986; Burton et al., 1990). As such, a FRU must store invariant descriptions of a familiar face which can be activated, allowing for its accurate identification and distinction from other faces, even if the visual input is received from a previously unknown image (Ritchie & Burton, 2017), a novel viewing condition (e.g. viewing angle and expression manipulations by Bruce, 1982), variable environmental context (e.g. Dalton, 1993) or is degraded (e.g. matching familiar vs unfamiliar identities from CCTV footage, Bruce et al., 2001). According to the above models, this robust representation is not present for unfamiliar faces (Burton et al., 1990; Burton et al., 2011), further pointing at the qualitative distinction between how familiar and unfamiliar faces are processed.

Consequently, it is necessary to identify and highlight the processes necessary to build the abstract FRU and thus gain familiarity with a face (Burton et al., 2016). This process was hypothesized to be facilitated by repeated exposure to a face (Liu et al., 2009; Kramer et al., 2018). According to Jenkins et al. (2011), the degree of familiarity we hold with a specific face depends on the range of its within-person variability we have experienced over successive encounters while learning to identify it. This contributes to forming a robust representation, capturing the information about how a specific face may vary under everyday conditions, depending on the changing and image-invariant characteristics of the person (e.g. weight, age, hairstyle, make-up), relevant image conditions (e.g. lighting, viewpoint), camera characteristics (e.g. exposure, focal length), their facial expression, pose and more (Burton, 2013; Kramer et al., 2018).

Contemporary research has stressed the importance of using "ambient" images to measure face learning or for subsequent comparisons of differences in unfamiliar and familiar face recognition (see Figure 3 in Chapter 2.2). These capture the natural variability of a face, allowing us to investigate how these stimuli are processed in real-life (Burton, 2013; Bindemann & Hole, 2020). Recent empirical findings have confirmed that learning faces from multiple ambient images incorporating high within-person variability has led to improved performance during face recognition and matching tasks (e.g. Longmore et al., 2008; Kaufmann et al., 2009; Andrews et al., 2015; Ritchie & Burton, 2017; Koca & Oriet, 2023). This improvement in recognition extended not only for the pictures used during training, but also for previously unseen images of the person, showing how this form of learning can lead to the formation of image-invariant representations (White et al., 2014). Importantly, Burton et al. (2016) found that this within-person variability is to an important extent idiosyncratic – to become familiar with a face, we must learn how this *particular face* can vary. Such evidence has also led to an assumption that we have not been exposed to sufficient variability of an unfamiliar face to isolate its image-invariant elements and build a FRU, which may be why having to match different images depicting the same unknown person can be very difficult (Jenkins et al., 2011; Andrews et al., 2015; Koca & Oriet, 2023). This again suggests that we process familiar and unfamiliar faces qualitatively differently. Nonetheless, behavioural research can only inform us about the *outcomes* of cognitive sub-processes underlying the distinction between our mental representations of familiar and unfamiliar faces (Andrews et al., 2017). The neural underpinnings of this phenomenon will be addressed in more detail in the following part of this work (see Chapter 1.3.1) and further investigated by the experiments in Chapters 3-5.

1.3.1. Neural Correlates of Familiar Face Recognition

Neuroscientific research has provided essential insight into neural correlates of the image-invariant processing and recognition of known faces which are of particular interest for the following project. Haxby et al. (2000) proposed a functional model describing the neural network mediating face processing. The researchers distinguished between a core system, involved in visual processing of faces, and an extended system, engaged in the extraction of meaning from face stimuli, including information related to an individual's intentions, verbal speech analysis, guiding how we direct our attention and retrieve related person knowledge (Gobbini & Haxby, 2007; Haxby et al., 2000).

Related brain imaging research utilising functional MRI characterised the occipital face area (OFA), fusiform face area (FFA), and posterior superior temporal sulcus (pSTS) as face-selective regions belonging to the core system (Haxby et al., 2000; Ramon & Gobbini, 2018). More recent findings have supported the anterior temporal face area (ATFA), the anterior superior temporal sulcus (aSTS-FA), and the inferior frontal gyrus (IFG-FA) as additional parts of the visual face analysis system (e.g. Carlin et al., 2011; Duchaine & Yovel, 2015; Visconti di Oleggio Castello et al., 2017). Guntupalli et al. (2017) uncovered image-dependent responses to familiar faces in the early visual cortex and the OFA, whereas the ATFA and the IFG-FA were shown to hold the more view-invariant representations of familiar faces. Visconti di Oleggio Castello et al. (2017) applied multivariate pattern analysis (MVPA) to fMRI and compared the brain's responses to personally familiar and unfamiliar faces. Familiarity was decoded in the posterior core system, the anterior temporal lobe and the inferior frontal cortex (Guntupalli et al., 2017; Visconti di Oleggio Castello et al., 2017; Ramon & Gobbini, 2018). Additionally, the medial temporal lobe (MTL) showed view-invariant adaptation only to familiar face images (Weibert et al., 2016), while its activity has been significantly modulated by personal familiarity across the amygdala, hippocampus and perirhinal cortex (Ramon et al., 2015). Intracranial recordings performed by Quiroga et al. (2005) detected a subset of hippocampal neurons which selectively activate in response to different images of the same familiar celebrity face. Therefore, it is possible to localize the areas of the brain particularly relevant for successful and view-invariant recognition of familiar faces.

Analysis of electrophysiological research can provide an additional level of insight into the temporal dynamics of familiar versus unfamiliar face recognition, and the qualitative differences in how these are processed.. Event-related brain potentials (ERPs) are voltage changes in the electroencephalogram (EEG) that reflect the summed electrical activity of post-synaptic potentials, recording the neural activity of the brain (Jackson & Bolger, 2014; Andrews et al., 2017). These are time-locked to specific events (e.g. visual stimulus presentation) and are captured as a series of positive or negative waveform peaks – the so-called "components" (Wiese et al., 2017). Face-selective ERP components can be related to specific stages of perceptual and cognitive processing of face stimuli (Gosling & Eimer, 2011; Andrews et al., 2017).

The *N250* effect is an ERP effect found at occipito-temporal electrodes which peaks approximately 250ms (from around 200-400ms) after stimulus onset and has been repeatedly found sensitive to face familiarity, especially over the right hemisphere (Tanaka et al., 2006; Kaufmann et al., 2009; Gosling & Eimer, 2011; Schweinberger & Neumann, 2016). This effect has been uncovered by consistent empirical findings. During an explicit face recognition task, Gosling & Eimer (2011) found a pronounced difference between the ERP waveforms elicited by familiar celebrity faces and by unfamiliar faces. This was sensitive to the degree of familiarity, with more negative-going amplitudes for faces overtly judged as "definitely known" rather than merely "familiar". Additionally, Andrews et al. (2017) measured changes in the N250 to provide convincing evidence for the previously underlined importance of variability in the acquisition of stable and image-invariant representations of faces essential for familiar face recognition (see Chapter 1.3). Participants engaged in an implicit learning task during which they had to sort images of unfamiliar faces into two piles - one per identity. The stimuli were intended to capture the "natural variability" of a face one may experience when meeting a new person. Learning new faces from stimuli capturing high within-person variability elicited a corresponding N250 effect, with more negative-going waveforms detected for the newly learned faces relative to unfamiliar faces. There was no difference in the ERPs elicited by previously seen and unseen photographs of the familiar face, suggesting that image-invariant representations can be acquired via implicit learning, which are in turn reflected by changes in brain activity that do not appear for unfamiliar faces (Andrews et al., 2017).

Subsequent research has further investigated whether the N250 is predominately automatic or reliant on attentional resources, task type and demands. Eimer et al. (2012) investigated the ERP correlates of face recognition in individuals with Developmental Prosopagnosia (DP) - a condition associated with an impaired ability to recognize and identify familiar people from their faces, despite the patients' normal vision and intellect (De Renzi et al., 1991). Although the participants did not confirm the familiarity with any celebrity face when making explicit ratings, researchers found a preserved, covert ("implicit") N250 familiarity effect in the ERPs of 6 out of 12 subjects (Eimer et al., 2012).

Additionally, Wiese et al. (2019b) exposed participants to ambient images of familiar and unfamiliar faces with letter strings superimposed on each photograph, manipulating the attentional load necessary to perform the task by requiring participants to either detect a specific letter from a string of identical letters ("low load") or a string of different letters ("high load"). Researchers demonstrated that the N250 is reliably elicited by the images of familiar faces, even when a person is undergoing tasks highly demanding of their attentional resources (Wiese et al., 2019b). Wiese et al. (2022a) further demonstrated that the difference between the amplitudes elicited by a variety of naturalistic images depicting personally familiar and unfamiliar faces remains significant from around 200ms after the onset of the stimulus, even when participants are asked to conceal their familiarity with the face when making explicit judgements.

Therefore, it can be concluded that the N250 familiarity effect likely reflects relatively automatic access to a long-term visual representation of a familiar face resulting from a match between the perceptual input from a seen face and its trace in our memory that is not present for unfamiliar faces (see "Face Recognition Units" in the model by Bruce & Young, 1986; Gosling & Eimer, 2011; Schweinberger & Neumann, 2016; Andrews et al., 2017; Wiese et al., 2019b). Still, the ERP components elicited by familiar faces around 250ms after stimulus onset can vary depending on our recent perceptual experiences preceding the presentation of a familiar face, as demonstrated by the so-called N250r effect (Schweinberger et al., 1995; Schweinberger & Burton, 2003; Schweinberger & Neumann, 2016) which will be explored in Chapter 1.5.2. The behavioural and imaging findings discussed above have been highly specific to face rather than person recognition. It is essential to note that recognition of faces is necessary to interact with people during social situations, however, this ability is generally more complex than simply determining whether a face we encounter is known or not. The process of familiar *person* recognition cannot be fully understood by investigating perceptual stages of familiar face processing and should be explored further (Schwartz & Yovel, 2019).

1.4. Person Identity Nodes – How do we recognize a person?

Since this thesis will be predominately concerned with the cognitive underpinnings of *identity recognition*, it is additionally essential to emphasise the processes allowing people to not only remember what a familiar individual looks like, but also how to retrieve and integrate additional person-specific knowledge via the conceptual processing of semantic, episodic and/or affective information. *Person knowledge* can be defined as information we hold about a familiar person's traits, social network, biographical data, attitudes, intentions and transient mental states (Ramon & Gobbini, 2018). Our ability to access it allows us to quickly and accurately match the long-term memory representation of a known face to a specific identity for successful social interactions, which is considered one of the most essential purposes of face recognition (Avery et al., 2016; Wiese et al., 2022b).

The IAC model by Burton et al. (1990) proposed that all familiarity decisions are made at the level of *Person Identity Nodes* (PINs; see Figure 1). PINs are domain-general representations of a known person, which means they can be activated via any relevant input from an associated domain-specific modality, i.e. after viewing a face, a name or even hearing the voice of an individual that is matched with their stored representation. Familiarity is signalled once the PIN holding a representation of a specific person is activated above a specific threshold (Burton et al., 1990; Young & Burton, 1999; McNeill & Burton, 2002). Subsequently, a unit within the pool of PINs can activate and facilitate retrieval of identity-specific knowledge (e.g. their nationality, occupation, etc.) stored about the familiar person in *Semantic Information Units (SIUs).* Multiple PINs may possess a bi-directional connection to the same SIU, which explains the fact that a single semantic feature (such as a specific nationality or occupation) is often shared by several people we know. Once a SIU is activated above threshold, its signal can feed back into the associated PIN representations and facilitate recognition (Young & Burton, 1999; Wiese, 2011; Wiese et al., 2017). Therefore, the IAC architecture provides a detailed explanation of cognitive processes underlying not only individual face, but also person recognition and the retrieval of identity-related information. Existing empirical research can be related to the underlying assumptions of Burton et al.

(1990) and modelling efforts discussed above (Young & Burton, 1999; Schweinberger & Burton, 2003), while highlighting any areas requiring further investigation.

For instance, Barsics & Brédart (2012) applied a face learning paradigm during which participants were instructed to memorise semantic information (i.e. occupation) or the name of previously unknown people alongside their face *or* voice. Retrieval of person-related information was enhanced by the presentation of face and voice cues, with an advantage for face stimuli. The paradigm applied by researchers emerged from their criticisms of prior research (e.g. Hanley & Turner, 2000) for investigating the retrieval of semantic knowledge facilitated by visual or auditory input related with a specific person, proposing that the pre-established paradigms did not allow researchers to control for the type and strength of an association between the stimuli used during recognition tasks (Brédart et al., 2009; Barsics & Brédart, 2012).

Moreover, Schwartz & Yovel (2016) manipulated the context in which participants had to gain familiarity with different faces. They were learning faces from stimuli rich in perceptual information (e.g. many viewpoints/angles/illuminations) or conceptual information (e.g. person-related labels, occupation/name). View-invariant recognition of the newly familiar individuals was most notably improved by learning their faces from stimuli where meaningful identity-specific semantic information was attached (Schwartz & Yovel, 2016). Recent research has further emphasized the importance of studying real-world person recognition by exposing participants to naturally varying faces while watching a movie from a sequence which either preserved the *contextual information* about the characters or not. The acquisition of conceptual knowledge about specific people significantly benefitted subsequent recognition of their faces (Noad & Andrews, 2024). Although such results may be representative of a link formed between the PINs and SIUs modulating familiar person recognition (Brédart et al., 2009; Barsics & Brédart, 2012 Shwartz & Yovel, 2016), it may also be possible that the participants' attention was drawn by the contextual information attached to a face, facilitating its learning and recognition (Gobbini et al., 2013). The importance of identity-specific knowledge in person recognition should therefore be further explored with pre-experimentally familiar stimuli.

In addition, as noted by Barsics & Brédart (2012) and Kramer et al. (2018), many empirical studies on person recognition conducted thus far have categorised stimuli into "familiar" or "unfamiliar", using the faces of celebrities that are either known or unknown (e.g. from a different country) to the participants. Alternatively, it is likely the case that the *degree* of familiarity we have with the face has a significant impact on how we process it (Wiese et al., 2019c; Wiese et al., 2022b). More recent research has made notable developments on this idea, pointing out the fact that we likely have encountered significantly more variability of the faces belonging to people we know well in real-life (e.g. relatives, friends) rather than celebrities we only see on 2-dimensional and highly edited images and who are generally characterised to fit a specific role or stylised for a performance (Johnston & Edmonds, 2009). Additionally, the degree of our familiarity with personally known faces may also vary significantly, ranging from minimal to long-term and deeply intimate, which will additionally be related to the amount of *person knowledge* we possess about the individual (see review by Ramon & Gobbini, 2018). Many studies have found that we are fast, efficient and accurate at recognizing personally familiar identities (Bahrick et al., 1975; Bruce et al., 2001; Balas et al., 2007; Ramon, 2015). We are also more likely to pay attention to faces of personally known people, even without conscious awareness (Gobbini et al., 2013). Clutterbuck & Johnston (2002) tested how fast and accurately a full-frontal view of a strongly familiar, moderately familiar or an unfamiliar celebrity face can be matched with the same person's internal features cut out from another image capturing the same face from a different viewpoint (i.e. a three-quarters view) by tasking participants to decide whether the two photographs show the "same" or a "different" person. The speed of accurately matching two photos of the same face based on their internal features was significantly related to the level of familiarity with the person, as the images of highly familiar faces were matched faster than these of moderately familiar or unfamiliar faces. Still, it remained unknown whether this effect is also present for people known in real-life (Clutterbuck & Johnston, 2002). Producing behavioural research that would accurately characterize any qualitative differences between our mental representations of faces associated with a significant (e.g. personal) degree of familiarity has been challenging, likely due to ceiling effects in performance on tasks measuring any form of familiar face recognition (Clutterbuck & Johnston, 2002; Burton et al., 2016; Wiese et al., 2022b).

This issue has been addressed by neuroscientific research which can be notably more sensitive to subtle differences in any cognitive processes modulated by familiarity with a person (e.g. Herzmann et al., 2004; Leibenluft et al., 2004; Tacikowski et al., 2011; Sugiura, 2014; Ramon et al., 2015; Visconti di Oleggio Castello et al., 2017; Wiese et al., 2022b). The following paragraphs will consider how such findings have been related to the established face processing systems (e.g. Burton et al., 1990) and used to further explain identity recognition.

1.4.1. Neural Correlates of Familiar Person Recognition

The cognitive underpinnings of person recognition can be decoded by investigating the changes in brain activity related to the differentiation between faces only known visually and ones associated with significant person knowledge. As per the Haxby et al. (2000) model of neural systems underlying familiar face recognition, the *extended system* for face perception is responsible for extracting the person-related knowledge and affective information attached to a specific familiar face (Haxby et al., 2000; Leibenluft et al., 2004; Gobbini et al., 2004; Gobbini & Haxby, 2007).

Initial functional neuroimaging research by Gobbini et al. (2004) has exposed participants to faces of personally familiar (friends/family), famous (celebrities) or unfamiliar people and scrambled images of faces, during a fMRI scan to investigate the role of *person knowledge* in modulating neural activity during face recognition. Personally known faces elicited enhanced activity in brain regions previously associated with *Theory of Mind* (ToM) – assigning mental states and attributes to other people (Frith & Frith, 2012; Ramon & Gobbini, 2018). Nonetheless, these findings should be interpreted with caution, as the methodology did not allow the researchers to control for the degree of *visual* familiarity differentiating the three categories of faces. It is difficult to determine whether the related brain regions' activity was modulated by person knowledge (e.g. semantic/episodic associations) or by the strength of the visual familiarity with the stimuli. We generally possess the most identity-specific information about the people who we also see very often, i.e. we likely encounter a close friend more than a celebrity, and thus have more visual experience with their face, which could have influenced the participants' neural responses (Kramer et al., 2018; Wiese et al., 2022b).

Still, similar results were replicated by Leibenluft et al. (2004), comparing the fMRI signal elicited by the brains of mothers viewing images of their child and an unknown child. Enhanced activation for deeply familiar faces was found in the *ToM* areas, but also the amygdala, clearly associated with a more intense emotional response. Such findings have been related to the possible role these regions have in the retrieval of semantic, episodic or affective knowledge associated with the person (Gobbini & Haxby, 2007).

More recently, Visconti di Oleggio Castello et al. (2021) utilised MVPA to subsequently compare the neural activity elicited by faces personally familiar to each participant and faces they only knew from visual stimuli (*visually familiar strangers;* as defined by Visconti di Oleggio Castello et al., 2021). The researchers identified neural codes which are shared across brains of different participants and capture distinct representations of familiar faces. Faces known personally by each participant were found to be uniquely represented in areas associated with the processing of semantic information and the *ToM, i.e.* social and emotional cognition – parts of the extended system described by Haxby et al. (2000). Even if the participants' familiarity developed during unique interactions with the personally known individuals, all of them had an overlapping neural code, likely reflecting the shared person knowledge activated by viewing their face. In this case, researchers characterized it as ranging from long-term episodic memories to semantic (e.g., occupation) information we associate with an individual. However, the specific type of person knowledge associated with the faces personally known by all participants was not controlled or described during the study (Thornton & Mitchell, 2017; Visconti di Oleggio Castello et al., 2021). Conversely, it is possible that these results were modulated by the degree of visual familiarity with the face stimuli, rather than the associated person knowledge. While the *personally familiar* faces were likely associated with substantial visual experience (Kramer et al., 2018; Wiese et al., 2022b), the *visually familiar strangers* were only familiarized with during the experimental procedure. Although these findings suggest that the brain areas responsible for *mentalising, social and emotional cognition* are generally activated by personally familiar faces, it is challenging to identify these as the precise neural signatures of identity-specific knowledge activation due to the possible influence of visual familiarity on the findings above (Gobbini et al., 2004; Leibenluft et al., 2004; Visconti di Oleggio Castello et al., 2021).

Even though fMRI findings have localized person recognition, it is still unknown how far the activation and integration of identity-related knowledge can be detected by analysing corresponding changes in electrical brain activity. Given the substantial temporal sensitivity of ERP measures, this experimental approach has been used to differentiate between the mental representations of highly familiar and unfamiliar faces (Campbell et al., 2020; Wiese et al., 2022b).

Although the N250 familiarity effect can be used to distinguish the neural activity elicited by visually familiar and unfamiliar faces (Tanaka et al., 2006; Gosling & Eimer, 2011; Andrews et al., 2017; Wiese et al., 2019b), studies thus far have been slow to investigate the neural underpinnings of strong personal familiarity with a face that could reflect the cognitive processes taking place during real-life person recognition (Wiese et al., 2022b). The N250 has been considered to reflect access to visual representations of a face (the FRUs; Bruce & Young, 1986; Schweinberger & Neumann, 2016), which is why it is unlikely to depict post-perceptual identity processing. ERP research using *associative priming* (see 1.5.4 for an in-depth explanation) has partially addressed this issue by presenting participants with two subsequent stimuli (a prime and a target) highly related to each other in terms of shared *person knowledge* (e.g. occupation, nationality; such as the face of Queen Elizabeth preceded by the name of King Charles). Apart from faster RTs, significantly more positive ERP waveforms over centroparietal electrodes have been detected for targets preceded by an associated prime from 300-600ms after the onset of a target. This shows that the pre-activation of identity-related knowledge with the prime may have modulated access to associated person representations and facilitated recognition (Schweinberger, 1996).

Moreover, more recent ERP research by Wiese et al. (2019c) compared the brain potentials elicited by highly personally familiar faces (e.g. close friends or relatives) versus unfamiliar faces, with all images used throughout the trials reflecting natural within-person variability. In addition to the N250 effect, this study successfully identified a ***Sustained Familiarity Effect (SFE)*** peaking between 400-600ms after stimulus onset. Familiar faces elicited significantly more negative amplitudes than unfamiliar faces at occipito-temporal channels – the SFE was confirmed to be relatively strong (~4 μV) and reliable (Figure 2*)*. Additionally, the findings of a follow-up experiment revealed a substantially larger SFE in response to personally well-known faces when compared with the neural responses to the faces of lesser-known lecturers, and particularly to celebrities. This at first sight seems to suggest that we possess a different type of a representation for celebrities and personally familiar faces, or in other words, that there exists a qualitative difference in how we process these. Alternatively, the observed differences may be quantitative and depend on the degree of familiarity we have with a face (Wiese et al., 2022b). In any case, the SFE was considered a significant neural marker of *person recognition*, effectively signalling the retrieval and integration of semantic or affective information associated with a familiar face. It was also noted that the nature of this effect should be further investigated, considering whether it can be manipulated by introducing any additional identity-related factors or task demands (Wiese et al., 2019c).

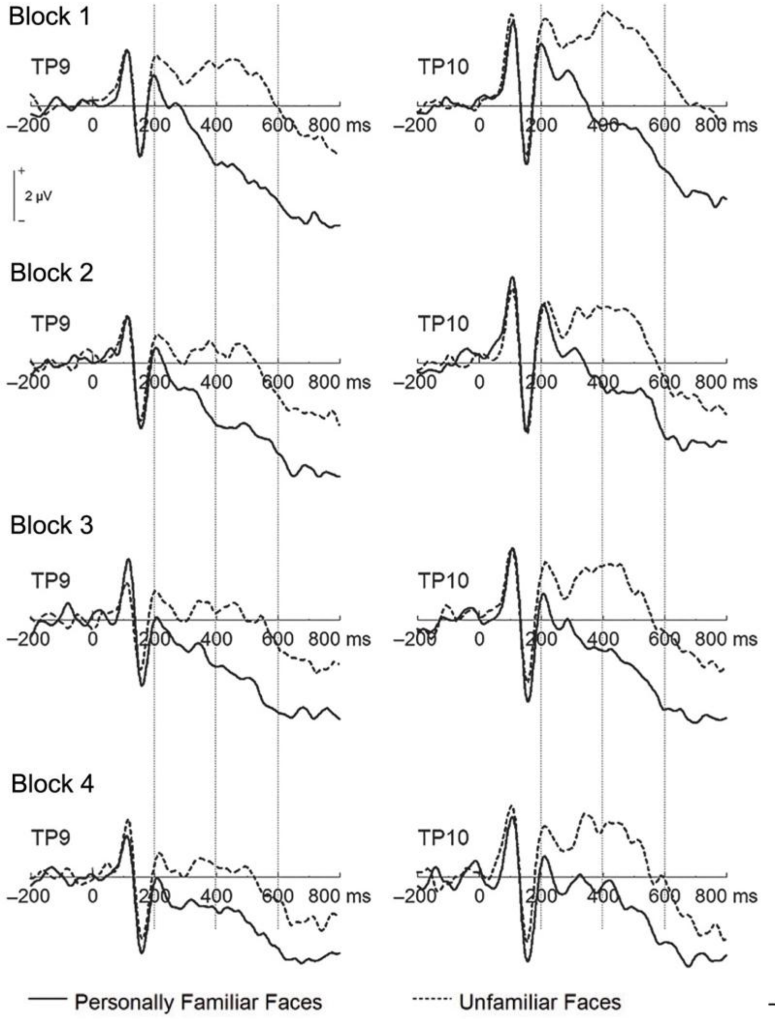

Figure 2. Adapted from Wiese et al. (2019c/Experiment 1): grand-average event-related brain potentials over left (TP9) and right (TP10) occipito-temporal electrodes, with separated waveforms elicited by personally familiar and unfamiliar faces. Note that that the difference between the solid (familiar faces) and dashed lines (unfamiliar faces) marks the familiarity effect ranging from around 200-600ms – the N250 and the subsequent SFE.

These initial results were followed up by Wiese et al. (2022b), attempting to examine whether the degree or type of familiarity (see 1.4.), but also any affective associations with a given individual, can influence the mental representations of familiar faces and *people*. ERPs elicited by faces of personally familiar people (relatives/close friends), favourite celebrities, disliked celebrities and unfamiliar (unknown celebrities/non-famous) people were compared. Significant familiarity effects (the N250 and the SFE) were detected in response to personally familiar and liked celebrities' faces, which clearly contrasted with the findings of Wiese et al.

(2019c). More negative-going ERP amplitudes were found for faces of people known in real-life than for celebrity faces, however, this effect was not consistently replicated. A clear SFE was also elicited by disliked, but well-known celebrities. Accordingly, it was concluded that personal familiarity is not associated with a qualitatively distinct cognitive representation. Any changes in the SFE likely reflect the degree of familiarity and identity-specific knowledge we hold about a person. These can be associated with quantitative differences between our neural responses to faces known from real-life interactions, media and unfamiliar faces (Wiese et al., 2022b).

It is also necessary to acknowledge that the previously described Wiese et al. (2019b; 1.3.1) study found that the SFE was significantly diminished in tasks with high attentional load. This has not been the case for the N250, which remained unaffected by such experimental manipulations. It was concluded that activating the visual representations of familiar faces is relatively automatic, while the subsequent processing stages are considerably more dependent on attentional resources. This suggests the N250 and SFE are likely *functionally distinct* (Wiese et al., 2019b; Wiese et al., 2023). Additionally, Wiese et al. (2022a) found that the N250 and the SFE do not vary depending on whether the task requires explicit or implicit familiarity judgements, which aligns with the previous results of ERP research on the earlier familiarity effect (Gosling & Eimer, 2011, Andrews et al., 2017). In sum, research outcomes thus far seem to indicate that the SFE represents post-perceptual processing stages, subsequent to the visual recognition of a face (reflected in the N250 effect), such as the integration of visual and semantic/episodic/conceptual identity-related information about the familiar person (Wiese et al., 2022b). Nonetheless, the findings above are not entirely conclusive. The studies discussed here have not directly manipulated the access to such person knowledge, but rather compared the neural responses to different types of familiar faces indirectly associated with varying degrees of familiarity (e.g. personally familiar, favourite celebrities, disliked celebrities in Wiese et al., 2022b). Therefore, the important properties of the SFE still remain unclear.

One problem with this conclusion has been uncovered by Wiese et al. (2023). This recent study investigated and compared the neural correlates of personal familiarity with personally familiar faces, but also animals, objects and scenes. The N250 effect at occipito-temporal electrodes was sensitive to highly familiar human and animal faces, but less right-lateralized for animals. However, a significant SFE was detected for all stimulus categories. These findings clearly contradicted the previous attempts to define the functional properties of the

SFE (Wiese et al., 2019b; Wiese et al., 2019c; Wiese et al., 2022a; Wiese et al., 2022b), since it is unlikely that familiar objects and scenes are associated with affective, episodic and/or semantic representations similarly rich as these held for well-known faces or animals.

As it stands currently, the cognitive processes underlying this clear effect are not yet fully understood. The most recent conclusion proposes that the sustained difference between the ERP components elicited by well-known and unfamiliar faces reflects a conceptual stage of processing which serves as preparation for a potential interaction with a highly familiar entity in our environment (Wiese et al., 2023). Nonetheless, it has been particularly challenging to define the extent to which the SFE represents the post-perceptual processing of conceptual information associated with familiar people, rather than reflecting a later stage of visual face recognition that distinguishes between known and unknown stimuli. Further research is essential to uncover the nature of the SFE and define its functional properties in more detail, which will be addressed by the present work.

The properties of the cognitive processes underlying the N250 and the SFE can potentially be disentangled with the use of priming (see 1.5. and related subsections), by investigating whether the introduction of additional, meaningful stimuli will have any significant impact on the neural activity during the visual or conceptual stages of face and person recognition (Wiese & Schweinberger, 2008; Stevenage & Spreadbury, 2010; Kutas & Federmeier, 2011; Schweinberger & Neumann, 2016; Mueller et al., 2020). The related theoretical background will be discussed in the following paragraphs, outlining the information necessary to implement priming in the current research and develop a greater understanding of the familiarity effects described above.

1.5. Priming Effects in Familiar Face Recognition

Past behavioural and neuropsychological research has utilized a wide range of priming paradigms to investigate the cognitive processes underlying familiar face and person recognition. Priming is a phenomenon used to investigate how recent experiences influence how we perceive and recognize stimuli (e.g. faces; Mueller et al., 2020). Although the priming procedure has been modified in a variety of ways to investigate a range of cognitive processes (e.g. Ellis et al., 1987; Lin & Liang, 2023), it generally involves presenting participants with two subsequent stimuli - a prime and a target, separated by a time interval that can be manipulated depending on the processes investigated (the prime/target stimulus onset asynchrony; SOA; Wiese, 2011). The main assumption underlying this method of studying face recognition is that the presentation of a familiar prime should facilitate the processing and recognition of a related target stimulus by pre-activating its mental representation, an associated cognitive network or concept (Ellis et al., 1993, Schweinberger et al., 1995, Mueller et al., 2020). As such, different forms of priming have been related to specific elements of the face processing systems described above, including the Bruce & Young (1986) and the Burton et al. (1990) models.

1.5.1. Domain-Specific Face Recognition – the Repetition Priming Effect

Repetition priming is observed when the same familiar stimulus is initially presented as the prime and then repeated as the target, facilitating faster and more accurate recognition of the target when compared to trials in which the prime and target are different. This phenomenon was first explored through linguistic research on the recognition of visually presented words (Ellis et al., 1987; Ellis et al., 1990). For instance, Scarborough et al. (1977) found that participants responded significantly faster to the second presentation of a word during lexical decision tasks. This effect had a robust and long-lasting impact on reaction times that was not influenced by whether the repeated words were visually different (lower vs upper-case letters; Scarborough et al., 1977). Additionally, evidence from object recognition tasks obtained by Warren & Morton (1982) showed that if an object's picture was viewed during a pre-testing phase, its recognition after a long time interval (45 minutes) was elicited at a lower threshold of exposure, regardless of whether the prime and target were identical or different images of the same object. These findings were not replicated for trials in which participants were presented with the object's name during the pre-trial phase, providing initial proof for the domain-specific nature of *long-lag* repetition priming (Warren & Morton, 1982; Johnston & Barry, 2001).

In turn, repetition priming has also been consistently found for the recognition of familiar faces (Young et al., 1986; Ellis et al., 1987; Roberts & Bruce, 1989). One of the classic studies on repetition priming in face recognition was conducted by Bruce & Valentine (1985) who tasked participants with a speeded familiarity decision task using celebrity face images. Importantly, long-lag repetition priming was used, where the prime presentation and target recognition was separated with a 20-minute filler task. Faster recognition in a familiarity decision task was observed in trials using identical faces as a prime and target, but also in the conditions during which participants were exposed to two different images of the same celebrity's face. The effect was long-lasting and much stronger in the former condition. However, this familiarity decision was not influenced by a prime which was the name of the celebrity whose face was the target, providing evidence for the fact that long-lag repetition priming does not cross stimulus domains (is *domain-specific*; Ellis et al., 1996; Bruce & Valentine, 1985). As additionally demonstrated by Ellis et al. (1990), the repetition of a familiar face did not facilitate the judgements of sex, or facial expressions exhibited by the recognized faces, suggesting that the repetition effect is predominately specific to familiarity decisions.

Before relating these findings to theoretical models, it is important to distinguish between *long-lag* repetition priming predominately used by early behavioural research in the field (Bruce & Valentine, 1985; Ellis et al., 1987; Ellis et al., 1996) and *immediate* repetition priming which will be discussed in Chapter 1.5.3 (e.g. Calder & Young, 1996). Classic repetition priming studies introduced a relatively long time interval between the prime and target, ranging from 5 minutes (e.g. Ellis et al., 1996) to 20 minutes (e.g. Bruce & Valentine, 1985; Ellis et al., 1987). In these cases, researchers found that familiarity decisions were successfully primed only by domain-specific input, where seeing a face would facilitate its recognition at a later encounter (Ellis et al., 1987). However, experiments where the prime and target are presented immediately after each other, with inter-stimulus intervals as short as 250ms, find a relatively short-lived priming effect which can be elicited by primes from another stimulus modality than the target (e.g. a prime name priming a target face, or *vice versa;* e.g. Experiment 4 in Young et al., 1994; Calder & Young, 1996). Cross-domain repetition priming did not influence person recognition when the prime and target were separated by a long time interval (e.g. 5 minutes; Burton et al., 1998). It was previously argued that the difference between the two repetition effects arises because they are facilitated at distinct loci within the face recognition system (Burton et al., 1990; Young et al., 1994). Therefore, the theoretical underpinnings of the long-lag repetition priming effect will be discussed below, which will be distinguished from the immediate repetition priming effect explored in Chapter 1.5.4.

The long-lag repetition priming effect was considered consistent with the notion of the Face Recognition Units established by the Bruce & Young (1986) functional model, assuming that priming works within a face recognition system. According to the serial processing architecture, any domain-specific input in the form of a prime should pre-activate the robust FRU, lowering the threshold value required for successful recognition of the familiar target, thus facilitating faster and more accurate familiarity decisions (Johnston & Barry, 2001; Schweinberger & Neumann, 2016). Since FRUs are characterised as domain-specific and image-independent representations, repetition priming should be reliably elicited by any view of a familiar face, which is in-line with the previous empirical findings (Bruce & Valentine, 1985; Ellis et al., 1990). An alternative explanation was that the long-lasting nature of long-lag repetition priming could reflect the strengthening of links between FRUs and PINs in the IAC model, where the second presentation of a face activates the PIN faster, facilitating recognition even after a considerable time interval (Burton et al., 1990; Calder & Young, 1996; Ellis et al., 1997).

The results obtained by Ellis et al. (1987) were similar to Ellis et al. (1990), providing additional support for the domain-specific nature of long-lag repetition priming for faces. The study found that the recognition of target faces was not significantly influenced by priming with the depicted individual’s name (using celebrities as stimuli) or with their body shape and clothing (using the subjects’ personal acquaintances as stimuli). Their final experiment found that the impact of repetition priming was mediated by the degree of prime and target similarity, with advantage for identical and very similar primes and targets (Ellis et al., 1987; Johnston & Edmonds, 2009). This suggests that long-lag repetition priming effect can be elicited by picture-based priming *and* image-independent priming, which will be explained in the next paragraphs (Burton et al., 1990). Ellis et al. (1987) argued that repetition priming relies on the re-activation of stored episodic memories from earlier encoding of a previously encountered face described by an “instance-based” model (McClelland & Rumelhart, 1985; Schweinberger et al., 1995).

In turn, Ellis et al. (1997) expanded on the structural account of long-lag repetition priming based on *the IAC model* by Burton et al. (1990), concluding that this phenomenon can be explained by the strengthening of between-pool connections in the IAC model (Calder & Young, 1996; Johnston & Barry, 2001). A prime image excites related units within *feature pools*, an additional set of pools introduced by Burton et al. (1990) to explain *pictorial* and *structural encoding* from the Bruce & Young (1986) model with the IAC architecture. Every face consists of a unique combination of features, which activate corresponding units within feature pools that organize specific visual characteristics or parameters of a face (e.g. in a simplified version of the model there is a distinct pool for mouths, hair or noses; Burton et al., 1990). These can be related to *pictorial codes* from Bruce & Young (1986), as these are also visual descriptions of an image generated during early visual processing of faces. If a prime is familiar, its FRU will receive input from the unidirectional connections it has with any feature units excited by the characteristics of a seen face. Once a FRU is active, it passes its activation to a corresponding PIN and strengthens their link following successful recognition. Target recognition is therefore facilitated, as the same FRU should now possess a stronger connection to the PIN which is relatively lasting, explaining long-lag repetition priming (Burton, 1994; Ellis et al., 1997).

Identical primes and targets share maximum overlap of their features, which primes the links between these feature units and the stored FRU, strengthening the FRU-PIN connection and facilitating target recognition. In this case, a match between the pictorial codes generated by a prime and target can further facilitate face recognition based on the *episodic and instance-based* memory formed for the image which has been viewed twice (Ellis et al., 1987; Bruce & Young, 1986). The repetition priming effect becomes weaker (but still reliable) when the prime and target are different photographs depicting the same identity, as the two stimuli share less features (Burton et al., 1990; Ellis et al., 1997; Johnston & Barry, 2001). As such, using two different images of the same person during repetition priming should be a more accurate way to measure image-independent face recognition, as it diminishes the influence of *pictorial priming* based on enhanced episodic memory for a specific photograph.

1.5.2. Neural Correlates of Repetition Priming – the N250r

The previously described ERP components (see Chapter 1.3) can be modulated by repeated presentations of the same face stimuli. This phenomenon has been identified as the N250r (r for repetition) effect (Schweinberger et al., 2002a; Neumann & Schweinberger, 2008). An *immediate* prime-target repetition elicits significantly more negative waveforms at occipito-temporal electrode channels relative to the non-repetition trials. This difference is particularly pronounced over the right hemisphere and starts at about 180ms, with a peak latency at 250ms after the onset of a target stimulus (Schweinberger et al., 1995; Schweinberger & Neumann, 2016; Wiese et al., 2017).

Related theoretical considerations identified the N250r effect as an electrophysiological marker of the perceptual processing stages necessary for successful familiar face recognition (Burton et al., 1990; Schweinberger & Burton, 2003; Herzmann et al., 2004; Schweinberger & Neumann, 2016). Because FRUs are abstract and image-independent representations of familiar faces, it should be possible to reliably activate these and facilitate recognition at the PIN level with any visual input depicting the known face, rather than a specific instance of it (e.g. a single picture; Kramer et al., 2018). Therefore, for the N250r to be considered a neural correlate of this process, it should be elicited by any image depicting a familiar identity - e.g. in trials where the prime and target are different photographs of a familiar face which have not been seen before (Wiese et al., 2024). The N250r should not be present for image-independent priming with unfamiliar faces.

Early studies used pictorial priming, detecting a smaller, but still significant N250r effect responding to unfamiliar *face image* repetition (Schweinberger et al., 1995; Schweinberger et al., 2002b), which would suggest that it may be related to the enhanced pictorial processing of visually similar stimuli. Still, numerous subsequent research has confirmed that the N250r effect can also be elicited by familiar faces, rather than only picture repetition. Experiments conducted by Schweinberger et al. (2002a) and Bindemann et al. (2008) revealed that although the N250r effect is stronger when a person is exposed to identical photographs of the same face twice, it is still reliably detected for identity repetition, where a prime and target are different and/or visually manipulated (e.g. stretched; Bindemann et al., 2008) photographs of the particular person. Faerber et al. (2015) expanded on this idea by revealing that the N250r can be facilitated by the repetition of faces which were matched on their “perceived identity” participants learned from anti-face stimuli. Altogether, it can be concluded that this ERP component likely reflects the strengthened activation of the robust memory representations of familiar faces.

This account was further explored by face learning research, investigating whether changes in the N250r can be associated with the formation of abstract and view-invariant face representations. Zimmerman & Eimer (2013) revealed that learning of unfamiliar faces during rapid face matching can lead to the formation of image-independent memory traces. The study then effectively demonstrated that the N250r for *identical* familiar or unfamiliar prime-target images could reflect the view-dependent perceptual processing of matching pictorial representations (Schweinberger et al., 2002a; Zimmerman & Eimer, 2013). Importantly, no image-independent repetition priming effect was detected in trials using different photographs of *unfamiliar* faces as a prime and a target. Meanwhile, the view-invariant recognition of familiar faces associated with robust memory representations was shown by an N250r effect for familiar identity repetition.

A number of studies have argued that the N250r is face-specific and can be modulated by the repetition of face stimuli, rather than the repetition of objects or inverted faces (Neumann et al., 2011; Schweinberger et al., 2004). Nonetheless, Engst et al. (2006) found a reduced, but significant N250r effect for repeated famous buildings, and the scalp topography of the effect overlapped with the N250r to repeated familiar faces. This suggests that the N250r may not be specific to stimulus category and instead reflects access to identity-specific representations of faces (FRUs, Bruce & Young, 1986) or other familiar items (e.g. Object Recognition Units; Ellis & Young, 1996), which can be facilitated by prime-target identity repetition (Engst et al., 2006).

Since then, the image-independent N250r has been used to uncover the properties of abstract face representations. For example, Wiese et al. (2019a) presented participants with contrast-negative, contrast-positive or contrast chimera (i.e. a contrast-positive eye region and the remaining parts of the face negative) face images as either primes or targets to test whether familiar face representations are built around the eye region. The N250r was the strongest when contrast-positive primes were used and significantly diminished even when the information in the eye region was preserved. This allowed the researchers to conclude that although the eye region is important for efficient face recognition, the activation of face representations in our memory strongly relies on information from the entire face (Wiese et al., 2019a).

Most recently, Wiese et al. (2024) utilized the N250r to investigate the temporal dynamics of image-invariant familiar face recognition, where the prime stimulus presentation time was varied from 33ms to 500ms. Implementing *backwards masks* eliminated any visual afterimages elicited by the prime presentation. Although backwards masks reduced the N250r, the ERP repetition priming was still reliably elicited by prime images that were a different photograph of the target face and presented even for very short periods of time. Such findings allow us to gain insight into the efficiency and reliability of familiar face recognition (Wiese et al., 2024).

Nonetheless, as highlighted by Schweinberger et al. (2002a), it is still unknown whether or how specifically the N250r priming effect is related to the difference in ERP components elicited by familiar and unfamiliar faces – the N250 familiarity effect and the subsequent SFE, as these have generally been studied separately (Schweinberger & Neumann, 2016). Using a methodology similar to Wiese et al. (2019b), Neumann & Schweinberger (2008) found a clear N250r effect which was similarly strong even if the participants had to engage in a task highly demanding of their attentional resources during prime presentations (i.e.

identifying target letters from letter strings superimposed face images). This demonstrates the N250r and the N250 may both be relatively automatic processes, possibly occurring at overlapping cognitive loci (Schweinberger & Neumann, 2016). Additionally, Zimmermann & Eimer (2013) detected a view-independent and robust N250r only after previously unfamiliar faces were learned by participants. Therefore, it has been established that both effects are sensitive to familiarity and domain-specific. Just as the N250r, the N250 can be enhanced by gaining familiarity with a face (Gosling & Eimer, 2011; Zimmermann & Eimer, 2013; Andrews et al., 2017). Therefore, it can be assumed that the N250 and the N250r are associated with a similar cognitive locus at the level of abstract mental representations for familiar faces which are activated automatically, irrespective of task demands.

At the same time, the magnitude of the SFE has been shown to be more strongly dependent on attentional resources (Wiese et al., 2019b) and task demands (Wiese et al., 2022a), in experiments where the N250 familiarity effect is reliably elicited. Meanwhile, the SFE can be found without the N250, for example, when ERPs to personally familiar versus unfamiliar scenes are compared (see 1.4.1.; Wiese et al., 2023). This double dissociation suggests that the N250 and the SFE likely reflect relatively independent processing stages involved in familiar face and person recognition (Wiese et al., 2022b). Investigating whether repetition priming has any significant impact on the early (N250) and later (the SFE) familiarity effects could provide essential insight into the nature of the cognitive systems underlying the difference between familiar and unfamiliar face or identity processing. The N250r should emerge automatically at the repetition of any stimuli depicting the known face, possibly enhancing the difference between the waveforms elicited by familiar versus unfamiliar faces from around 200ms after stimulus onset, as both have been considered to reflect the visual processing stages involved in familiar face recognition.

1.5.3. Cross-Domain Face Recognition – Self-Priming

As detailed previously, the IAC model (Burton et al., 1990) can be applied to provide an explanation of the long-lag repetition priming effect, detailing how a familiar prime can strengthen the FRU-PIN connection and allow these to more rapidly reach the threshold activation value necessary for successful recognition of a related target (Wiese et al., 2017). However, PINs are domain-general representations of familiar people’s identities. As such, their activity can also be facilitated via the pictorial input from a familiar name which subsequently passes onto the corresponding “name recognition units (NRUs)” and allows for the subsequent recognition of a known person if the related PIN is activated above a fixed threshold (Burton et al., 1990; Bruce & Valentine, 1985; Calder & Young, 1996; see Figure 1).

Since each PIN can receive activation from its connections with different pools of domain-specific units, it should be possible for the immediate repetition priming effect to cross stimulus domains. In cases where the prime and target are taken from different domains (e.g. a name prime and a target face, or *vice versa*), the repetition of the same identity should still successfully enhance the performance on familiar face recognition tasks. This effect has been identified as cross-domain ***self-priming*** and can only be found with immediate identity repetition priming (Burton et al., 1990; Calder et al., 1996a; Calder et al., 1996b; Wiese et al., 2017), where the prime and target are separated by a very short inter-stimulus interval (e.g. 250ms; Calder & Young, 1996).

Initial work by Calder & Young (1996) found that presenting a person with a name prime immediately before a target face significantly facilitates the speed at which the target is recognized. Still, in trials where a target was seen once, within-domain immediate repetition priming using different images of the same person's face produced stronger behavioural results than cross-domain priming (see Experiment 2 in Calder & Young, 1996). Researchers distinguished the theoretical underpinnings of cross-domain from within-domain repetition priming to explain why the latter produces stronger and more long-lasting behavioural results in familiarity decision tasks. They assumed immediate cross-domain self-priming was modulated only by enhancing the PIN activation, while the additional strengthening of the FRU-PIN or the NRU-PIN link was irrelevant for stimulating faster target processing if the prime and target came from different domains (Burton et al., 1990; Young et al., 1994; Calder & Young, 1996; Pickering & Schweinberger, 2003). Therefore, the locus of cross-domain immediate repetition priming should only be at the domain-general representations of familiar people's identities (Ellis et al., 1996; Jemel et al., 2005).

This self-priming (name-face) paradigm has been used throughout neuroscientific research to study the cognitive underpinnings of perceptual and conceptual processes involved in familiar face, but also identity recognition (Henson, 2003; Ambrus et al., 2019)

1.5.4. Neural Correlates of Self-Priming

Neuroimaging research investigating the neural correlates of the self-priming effect is significantly more limited than the studies utilising the within-domain repetition priming paradigm (Amado et al., 2018), perhaps due to the weaker behavioural effects it has been found to elicit or because its locus is at the more domain-general representations of familiar people (Calder et al., 1996).

Initial fMRI research by Amado et al. (2018) investigated the activity of brain regions associated with the significant effect of cross-domain priming on the shorter reaction times shown by participants during the study. The subsequent findings detected that the BOLD (blood-oxygen level dependent) signal was reduced in parts of the core system described by Haxby et al. (2000); the fusiform face area FFA and the occipital face area (OFA), when the name of a famous person was followed by a congruent target from another domain –the person's face. Researchers argued that the behavioural effects and the neural activity in these face-selective regions were driven by *predictive coding* after prime presentation, where the brain utilizes the provided name to predict the appearance of a face stimulus while engaging in higher-level processing (Amado et al., 2018). Subsequently, a relatively recent TMS study by Ambrus et al. (2019) again highlighted that the right occipital face area (rOFA) plays a significant role in the image-independent recognition of familiar face stimuli. Participants responded faster to varied familiar target face images preceded by the name of the depicted person (e.g. the written name of "Angela Merkel" followed by an image of her face). However, this self-priming effect was reduced when the rOFA was stimulated with TMS exactly at target onset, while enhancing the relative accuracy of subjects' responses to familiar targets in the unprimed trials (Ambrus et al., 2019). This supports the role of the rOFA in view-independent familiar face recognition likely facilitated by top-down input to the OFA triggered by the name prime during self-priming. Therefore, it can be concluded that cross-domain repetition priming is an experimental manipulation which may inform us about the neural underpinnings of face recognition driven by top-down effects from domain-general representations back to the core network. It is likely modulated by predictive coding, where the brain may use the prime to predict a response to the target (Rauss & Pourtois, 2013; Olkkonen et al., 2017; Amado et al., 2018).

Electrophysiological research utilized cross-domain repetition priming to further explore the possible distinction between *face* and *person* recognition by analysing the corresponding temporal changes in neural processing. ERP studies detected a more negative component peaking around **400ms** after target onset for incongruent (i.e. relating to different identities) than congruent familiar prime-target pairs from different stimulus domains. This effect has been identified as the ***N400*** and typically measured at centro-parietal electrodes (Pickering & Schweinberger, 2003; Wiese et al., 2017). Jemel et al. (2005) primed celebrity faces with their respective names, detecting a clear difference in ERP amplitudes which lasted from 400-600ms and was highly sensitive to familiarity, with significantly more negative waveforms elicited by primed familiar than primed unfamiliar targets. Additionally, Pickering & Schweinberger (2003) detected a clear N400 and no N250r effect during cross-modality repetition priming. It can be argued that the well-established N250r reflects access to robust domain-specific representations of familiar faces (Schweinberger, 2011), while the N400 is most likely associated with an enhanced activation of domain-general person representations accessed via lower-level units stimulated during priming (Wiese et al., 2017).

Based on these findings, several researchers proposed that this later ERP component may additionally reflect the facilitated integration of semantic information about the person whose identity is repeated, arguing that domain-general semantic units can be stimulated by any input (e.g. a name prime) and interact with the PINs by further enhancing their activation to reach a given threshold (Burton et al., 1990; Pickering & Schweinberger, 2003 Jemel et al., 2005). According to the IAC model, the influence of cross-domain priming on identity processing during person recognition converges at the PIN level (Burton et al., 1990). However, research using this self-priming paradigm has not yet successfully established whether the corresponding N400 effect is indeed reflective of any additional input from units storing semantic information about the familiar person (e.g. person-related knowledge). Wiese et al. (2017) addressed this issue by demonstrating that the N400 effect modulated by cross-domain *repetition priming* was significantly diminished in older (compared to young) participants, while a N400 elicited by cross-domain *semantic* priming, an experimental manipulation requiring subjects to access domain-general semantic knowledge about a familiar person (see Chapter 1.5.5), was spared. This suggests that the N400 effect produced by cross-domain repetition priming is more strongly related to enhanced ability to access identity-specific representations of familiar people through bottom-up processing units (e.g. NRUs to PINs; Burton et al., 1990; Wiese et al., 2017), without the retrieval of additional conceptual/semantic person knowledge.

Therefore, self-priming could be applied to investigate whether the difference in ERP components elicited by familiar versus unfamiliar faces and present from 400-600ms (the SFE; Wiese et al., 2019c; Wiese et al., 2022b) is related to the post-perceptual processing of person representations stored at the level of domain-general PINs, rather than the processing of purely perceptual representations of faces. Since neural correlates of the cross-domain repetition priming effect (the N400) and the SFE show overlapping temporal dynamics (e.g.

Wiese et al., 2019c), it could be possible that a similar stage of cognitive processing is engaged in the processing of familiar face stimuli in this time window. Therefore, it can be predicted that the SFE should be modulated by self-priming in the time range of the N400.

In turn, the related processes may also be influenced by predictive coding, where our neural activity is modulated by whether there is a match between the predicted stimulus (e.g. based on the name) and the actual sensory input (the face; Friston, 2012; Rauss & Pourtois, 2013), which was previously identified when using self-priming during the corresponding fMRI research (Amado et al., 2018). This could be examined with response priming during a familiarity decision task, where participants are instructed to respond to a target stimulus as quickly as possible (e.g. with a button press). A target is proceeded with a prime which can either be mapped to the same (*consistent/congruent* prime) or a different response than the target (*incongruent/inconsistent* prime; Schmidt et al., 2011). In a person recognition study, a prime and a target representing the same identity would be linked to the same response in congruent trials, e.g. a button assigned to the familiar/unfamiliar category. To respond accurately, the participants would have to integrate the information about the familiarity of the prime and the target in each trial. As such, this experiment will additionally utilise response priming, investigating if any incongruence between the prime and the predicted familiarity decision to the target will have a significant influence on the participants' neural activity.

Analysing and comparing the ERP components manipulated by within and cross-domain priming in relation to the well-established familiarity effects (the N250 and the SFE) may inform our understanding of the distinction between how we process familiar faces versus familiar *people* (Wiese et al., 2023). Therefore, it is necessary to conduct an analysis of whether the N250 or the SFE are related to image-independent perceptual processing, access to stored person representations or the retrieval of identity-specific (e.g. semantic) knowledge associated with a familiar face stimulus. While the first two can be investigated with the comparison of the influence within-domain and cross-domain repetition priming have on any corresponding changes in neural activity, the latter hypothesis can be addressed by applying *associative priming*.

Therefore, the last component of familiar face recognition essential to successfully identify a well-known person – the retrieval and integration of identity-related knowledge, and whether it is significantly related to the differences in how familiar and unfamiliar faces are processed, will be explored in the following paragraphs.

1.5.5. Domain-General Face Recognition - Associative Priming

Semantic processing refers to our ability to utilise the general, conceptual knowledge we have about the world to make sense of the environment and engage in cognitive tasks, such as interacting with objects or people and making links between relevant concepts (Lambon et al., 2009; Joyal et al., 2020). Therefore, semantic *person knowledge* should refer to the conceptual information we hold about an encountered individual (e.g. hobbies, occupation, nationality, etc.; Bruce & Young, 1986). It is plausible to assume that we hold an extensive amount of semantic knowledge about highly familiar individuals, whereas no such information is associated with completely unknown people. Therefore, seeing a familiar face should facilitate not only its visual, but also conceptual processing of the person's identity and the integration of knowledge we hold about them (Burton et al., 2011; Schwartz & Yovel, 2019; Wiese et al., 2022b).

This cognitive process can be investigated with the *associative priming* paradigm. In contrast to the previously discussed priming procedures, associative priming is observed when people are reliably faster at making familiarity decisions about a target face stimulus when it is primed with a highly associated stimulus (Bruce, 1983; Wiese & Schweinberger, 2008; Wiese, 2011). It is important to note that, in contrast to within-domain or cross-domain priming, the prime and target are *never* the same person when associative priming is applied. For example, priming the face of Angelina Jolie with the face of Brad Pitt should elicit a significantly faster reaction than with the face of King Charles (Wiese & Schweinberger, 2008), likely due to a strong association between the two identities (both are famous, American actors who used to be married). Additionally, just as self-priming, this effect has been found to be relatively short-lived and only occurred if no intervening items were introduced between the prime and target (Bruce, 1986). It is also important that the associative priming effect can also *cross stimulus domains* (Wiese, 2011), which was first detected by Young et al. (1988) who found a significant effect of priming a target face with a highly related name (or *vice versa*). The researchers additionally proposed that this effect may reflect *covert recognition*, as cross-domain associative priming (prime face and name target) had a significant impact on the speed at which a prosopagnosic patient decided whether the target individual was familiar (Young et al., 1988).

According to the IAC architecture (see Figure 1), the retrieval of semantic person knowledge is achieved by the activation passing from a specific representation within the PIN pool to the corresponding SIUs. Since these pools share bi-directional links, once a specific SIU is active, it can pass its activation back to all PINs which are also connected to the particular semantic feature and bring their activity closer to the threshold necessary for successful recognition once the PIN receives any input from a domain-specific representation (the FRU or NRU; Burton et al., 1990; Wiese et al., 2017). For instance, seeing the face (or a name) of Queen Elizabeth would activate a related FRU (or NRU), strengthening the connection between the FRU and the PIN, which will pass its activation onto semantic units for "Royal" and "British". In turn, these should stimulate the PINs who are also connected to these features and facilitate the recognition of, for example, King Charles at the PIN level once a corresponding NRU/FRU is activated (Wiese, 2011). Therefore, this account would explain predominately categorical associative priming (Stone, 2008). Still, a prominent challenge in the research on associative priming has been to disentangle whether this effect stems from association based in co-occurrence (e.g. priming is elicited if two people who are often seen together are the prime and target), or purely semantic relatedness, where the two people occupy a shared category in our person memory (e.g. two people of the same nationality/occupation; Ellis, 1992; Carson & Burton, 2001; see Wiese, 2011 for a review).

Empirical findings have previously detected a stronger effect of co-occurrence and a weaker impact of categorical relatedness during semantic priming (Ellis, 1992; Carson & Burton, 2001; Stone, 2008). Vladeanu et al. (2006) utilized a learning paradigm with artificial faces and detected a priming effect when prime-target pairs of faces the participants learned were consistently visually co-occurring, without any semantic information introduced during the trials. A smaller effect of categorical association was found in a follow-up experiment. However, a more recent learning study by Wiese & Schweinberger (2015) found that the strongest behavioural associative priming effect was elicited by prime/target pairs which shared both - co-occurrence and semantic information. The researchers used a shorter SOA than Vladeanu et al. (2006) to eliminate any expectancy-based strategies which could have been used by participants to predict the occurrence of a target which was learned together with the prime face during training. Therefore, research thus far has provided relatively convincing evidence for a role of categorical relatedness in associative priming, showing that this paradigm can successfully facilitate the recognition of closely related familiar identities according to its explanation by the IAC model (Burton et al., 1990; McNeill & Burton, 2002; Wiese & Schweinberger, 2015).

Importantly, Stone (2008) used cross-domain associative priming, where the prime was a face image, and the target was a name. Participants were shown prime/target pairs who only shared a semantic category (i.e. occupation) before or interchangeably with prime/target pairs that were also closely associated based on their co-occurrence. A significant priming effect was found for same-category pairs when these were presented *before* the strongly associated stimuli. The researcher argued that stimuli showing high co-occurrence may catch a participant's attention and elicit a stronger behavioural response, suppressing the impact of a purely categorical connection during priming (Stone, 2008). Additionally, it is essential to note that visual co-occurrence may be less impactful than semantic relatedness on the associative priming effect when cross-domain priming is used (Wiese & Schweinberger, 2008), as faces and related names do not tend to be shown together very often.

Still, it becomes even more difficult to distinguish between the two when attempting to apply associative priming to investigate how the retrieval of identity-specific person knowledge is related to the early visual processing stages (Wiese & Schweinberger, 2015). It is nearly impossible to confidently measure or manipulate the amount of visual co-occurrence or semantic relatedness shared by people we know in real-life for empirical testing. Nonetheless, even the learning studies (e.g. Vladeanu et al., 2006 or Wiese & Schweinberger, 2015) arguably did not provide the extent of semantic information about the newly encountered faces that would equal the amount of identity-specific knowledge we associate with people we are very close with (e.g. friends or family members; Wiese et al., 2022b). The present project will apply the cross-domain associative priming technique to investigate whether the cognitive underpinnings of familiar face and identity recognition can be modulated by facilitating the access to person knowledge, using more naturalistic stimuli as primes and targets.

To implement this approach, it is first necessary to establish whether this paradigm can demonstrate how our brain processes the faces of familiar people and inform us about the cognitive processes behind person recognition.

1.5.6. Neural Correlates of the Associative Priming Effect

The associative priming effect has been investigated in more depth with electrophysiological research, specifically the ERP measures influenced by the presentation of closely associated/unrelated prime-target pairs (Wiese & Schweinberger, 2015). A well-established electrophysiological marker of the associative priming effect during person recognition is the N400 component. Significantly more negative-going amplitudes have been observed for unrelated relative to closely associated prime-target pairs from 300-600ms, peaking around 400ms after target onset and specifically pronounced over centroparietal electrodes (Schweinberger et al., 1995; Schweinberger, 1996; Wiese, 2011; Joyal et al., 2020).

One of the seminal priming studies by Schweinberger (1996) utilised within- and cross-domain associative priming, where participants were exposed to faces/names of famous people preceded by the faces/names of a highly related well-known person. The N400 was detected, with target faces preceded by related relative to unrelated prime stimuli eliciting less negative waveforms at centroparietal sites, with reversed polarity over prefrontal electrodes. No N250r priming effect and no significant difference between the amplitudes elicited by cross- and within-domain priming in the N400 were detected (Schweinberger, 1996). This provided initial proof for the suggestion that associative priming facilitates post-perceptual processing of domain-general person representations, which can be differentiated from the neural underpinnings of early visual processing stages preceding person recognition (Schweinberger et al., 1995; Schweinberger, 1996; Burton et al., 1990). Wiese & Schweinberger (2008) attempted to disentangle any differences between the neural responses to priming with closely associated or categorically related prime/target pairs (Ellis, 1992; Carson & Burton, 2001) and found that the N400 was only present over the left parietal electrodes and clearly diminished in the categorical priming condition relative to the strong central N400 found for associative priming. Additionally, only the categorical priming condition elicited a parietal P2 component (from around 200-300ms), with more positive waveforms for primed than unprimed conditions, suggesting both forms of priming are qualitatively different. However, such findings were alternatively interpreted as a form of strategic, potentially expectancy-based processing, where participants would utilize the prime presented for a long time (1,200ms) to predict the target (Wiese & Schweinberger, 2011; Wiese, 2011).

Wiese & Schweinberger (2011) tested participants with a cross-domain associative (prime/target that co-occur and share semantic information) and categorical priming (prime/target sharing only occupational information) design, aiming to reduce any potential influence of expectancy-based strategies which could have impacted the results of the previous study (Wiese & Schweinberger, 2008). This was achieved by presenting name primes masked with letter strings before face targets and manipulating the prime/target SOA to explore the temporal dynamics of the corresponding ERP components. In the short SOA condition (33ms), both forms of priming elicited a significant N400 effect, which diminished in the long SOA condition for categorically related prime/target pairs (1033ms). Researchers proposed that both forms of priming have a shared mechanism that is in-line with the IAC architecture, where initially several categorically related person representations are automatically activated by priming with shared semantic information. However, only very closely associated PINs are likely to remain active at longer SOAs (Burton et al., 1990; Wiese & Schweinberger, 2011). Finally, the learning study by Wiese & Schweinberger (2015) included an additional ERP measure, revealing a significant N400 for conditions in which the associated prime and target faces were learned from visual co-occurrence alongside attached shared semantic (*identity-specific)* information.

These findings support the suggestion that associative priming can be explained by the IAC architecture and that the N400 reflects the post-perceptual processing stages preceding the recognition of *familiar people*, not just their faces. Still, it is also possible that expectancy-based strategies, or the more automatic predictive coding, have a significant influence on neural processing when attempting to predict the target based on the information provided by the prime stimulus (Wiese, 2011; Amado et al., 2018). In research using, for instance, a familiarity decision task, participants would have predicted the prime and target to be connected to the same categorical response (i.e. familiar/unfamiliar button press). Therefore, potential influence of response priming will be examined to determine whether the integration of information provided by the prime name and the target face needed for an accurate familiarity response (i.e. whether each stimulus is familiar or not) elicits any significant changes in the participants' ERPs to faces (Schmidt et al., 2011).

Nonetheless, this priming technique may be used alongside cross- and within-domain repetition priming to investigate the functional underpinnings of the SFE (see 1.4.1). The temporal dynamics of the N400 associative priming effect overlap with the SFE quite closely, yet these two ERP components have never been studied together (Wiese et al., 2019c; Wiese et al., 2022b). Therefore, manipulating the context (i.e. via the prime) in which a familiar or unfamiliar face is viewed and measuring the strength of the familiarity effect across the priming conditions should allow to establish the extent to which the SFE is reflective of post-perceptual processing of semantic or other identity-specific information attached to the prime and target. Alternatively, it will be possible to examine any potential impact of strategic processing/predictive coding on the SFE (Wiese, 2011; Amado et al., 2018).

The term *associative priming* will be used throughout the present paper to avoid confusion or misattribution of the effect's cognitive underpinnings to purely semantic factors while overlooking the importance of co-occurrence, since Experiment 2 will use associated, co-occurring prime/target pairs.

1.6. The Aims of The Present Study

The introductory sections have elaborated on the important distinction between visual processing of familiar and unfamiliar faces (see 1.3., 1.5.1 and 1.5.2.), allowing us to discriminate between faces we know from any input, and the post-perceptual processing of *person knowledge*, which is essential for successful social interactions in everyday life. These processes have been explained with the well-established cognitive models of face recognition (Bruce & Young, 1986; Burton et al., 1990).

Evidence comparing how unfamiliar and familiar faces are processed has consistently detected reliable differences in the ERP components elicited by stimuli with different degrees of familiarity, ranging from completely unfamiliar to known personally (e.g. Kaufmann et al., 2009; Gosling & Eimer, 2011; Wiese et al., 2019c; Wiese et al., 2022a; Wiese et al., 2022b). This significant difference in amplitude starts at around 200ms, reflecting the N250 effect (Gosling & Eimer, 2011; Schweinberger & Neumann, 2016), and becomes particularly pronounced from 400-600ms, which has been more recently identified as the SFE. Even though the N250 familiarity effect has been previously associated with automatic, image-invariant processing of familiar face stimuli (or the access to domain-specific FRUs; Bruce & Young, 1986), the functional properties of the SFE are still not fully known (Wiese et al., 2022b).

First, it has been hypothesized to reflect access to and integration of semantic or affective *person knowledge* elicited by a highly familiar face, especially because the magnitude of this effect was notably decreased for lesser-known faces (e.g. lecturers or lesser known celebrities) in comparison to seeing highly personally familiar people (Wiese et al., 2019c). However, this interpretation was not entirely supported by subsequent findings, revealing SFE-like components for non-face stimuli (such as personally familiar objects or scenes) at occipito-temporal electrodes, suggesting that this effect might be more reflective of an activation which prepares the cognitive system for a potential interaction with a highly familiar item we see in our environment (Wiese et al., 2023). Still, the findings are not entirely conclusive and the research on this effect is still limited due to its novelty.

The aim of the present study is to utilize three different priming techniques to establish the extent to which the Sustained Familiarity Effect (the SFE) is reflective *of post-perceptual processing* of identity-related (e.g. semantic) information about a highly familiar person, rather than *visual processing* and access to the long-term perceptual representations of faces preceding familiar identity recognition.

As highlighted previously, *priming effects* (the difference in ERP amplitudes elicited by primed versus unprimed faces) can be combined with the established familiarity effects (the difference in ERP amplitudes elicited by familiar versus unfamiliar faces), as it has been previously shown to have a significant impact on different levels at which face stimuli are processed, ranging from perceptual to higher-level conceptual processing (Schweinberger et al., 1995; Wiese et al., 2017; Mueller et al., 2020). If a priming effect associated with a specific cognitive processing level will significantly influence the waveforms responding to familiar/unfamiliar faces, it may be possible to assume that the amplitude changes at relevant time points are related to an overlapping stage of face or person recognition. Additionally, the work will aim to disentangle the influence of predictive coding on the amplitudes elicited by cross-and within-domain priming, investigating whether the SFE is modulated by the expectation of an upcoming categorical response to the target (familiar or unfamiliar) elicited with response priming.

Therefore, the following predictions will be tested with three experiments utilizing self-priming (cross-domain repetition priming; see 1.5.3, 1.5.4.); associative priming (see 1.5.5. & 1.5.6.) and repetition priming (see 1.5.1. & 1.5.2.):

1. Self-priming using cross-domain prime/target pairs (i.e. prime names and face targets, e.g. Wiese et al., 2017) will not have a significant influence on the N250 familiarity effect, assuming it reflects the enhanced activation of the PIN via the FRU (Bruce et al., 1990; Calder & Young, 1996; Pickering & Schweinberger, 2003; Wiese et al., 2017). In addition, if the SFE is associated with access to domain-general person representations (i.e. PINs) via any adequate perceptual input, it should be significantly influenced by self-priming of *familiar faces* only (Ellis et al., 1996; Jemel et al.,

2005). In turn, we expect ERPs in the N400 time range to vary for familiar *and* unfamiliar faces, depending on whether the prime and target (familiar/unfamiliar) match if predictive coding of the response to an incoming target is involved at this stage of face recognition (Bruce, 1983; Wiese & Schweinberger, 2011; Wiese, 2011; Amado et al., 2018).

2. Associative priming using cross-domain prime/target pairs (i.e. name primes and face targets, e.g. Wiese & Schweinberger, 2008) should also not have any influence on accessing visual representations of known faces likely reflected in the N250 familiarity effect (Andrews et al., 2017; Wiese et al., 2022b). On the other hand, any significant impact of associative priming on the strength of the SFE would provide evidence for the role of identity-specific *person knowledge* integration in eliciting this amplitude difference (Ramon & Gobbini, 2018; Wiese et al., 2019c; Wiese et al., 2022b). In turn, we expect that the prediction of a categorical response (familiar/unfamiliar) to the target facilitated by priming would influence the N400 waveforms elicited by familiar *and* unfamiliar targets, whereas only the responses to *familiar* targets would be influenced by enhanced access to person knowledge elicited by a related prime.

   Similarly to the self-priming effect (see 1.5.4.), the associative priming effect elicits a N400 component (Wiese et al., 2017). The neural changes elicited by both priming techniques likely reflect the later stages of familiar face/person processing, since these are domain-general and can be easily differentiated from the early N250-like effects which have been manipulated by within-domain input (e.g. priming a face target with a familiar or unfamiliar face; Schweinberger & Neumann, 2016).

3. Repetition priming using within-domain prime/target pairs should have a significant influence on the N250 Familiarity Effect, increasing the negativity of amplitudes responding to primed familiar faces. No additional impact of repetition priming on the SFE is expected, as the SFE has been dissociated from the neural processing reflecting early perceptual processing of familiar vs unfamiliar faces (Wiese et al., 2019b; Wiese et al., 2024).

Overall, these experimental manipulations will be used to explore and identify how the changes in neural activity can be used to explain any significant differences between the cognitive processes involved in the processing of personally familiar and unfamiliar faces. This should inform current developments in the field of face recognition, contributing to the current research on late familiarity effects uncovered with recent ERP investigations, utilizing more natural ("ambient") stimuli of faces closely familiar (e.g. close friends/family members) and unfamiliar to the participant. To our knowledge, no prior research has addressed this question by investigating the functional underpinnings of the SFE with the use of priming techniques.

Chapter 2

General Methods

2.1. Stimuli

Every participant in Experiment 1 (Self-Priming), Experiment 2 (Associative Priming) and Experiment 3 (Repetition Priming) provided 25 different images each of two personally highly familiar people (such as family members or close friends not known from university), along with the individuals' first names (only in Experiment 1 and 2). Consent of the depicted persons was obtained through e-mail. Rectangles around the faces were cropped out of the original photographs, resized, copied into a frame of 190 × 285 pixels, and converted to greyscale (see Figure 3 for examples) using GIMP (Version 2.10.36).

2.2. Procedure

In each experiment, the stimuli were combined into prime/target pairs, where the prime was a face (Experiment 3), or a name (Experiment 1 and 2) and the target was always a face image. All participants were paired so that faces familiar to one participant were used as unfamiliar stimuli for the other participant. For example, as depicted in Figure 3, faces familiar to Participant 1 (ID1 and ID2) were unfamiliar to Participant 2, while faces familiar to Participant 2 (ID3 and ID4) were unfamiliar to Participant 1. Accordingly, the familiarity of identities was balanced across participants, as identical stimuli were used in each familiarity condition (Wiese et al., 2023).

Every experiment consisted of four conditions. In the Primed Familiar condition, a familiar target was preceded by a prime of the same (Figure 4a and 4c, Experiment 1 and 3) or a highly associated identity (Figure 4b, Experiment 2). In the Unprimed Familiar condition, a familiar target was preceded by an unrelated and unfamiliar prime (Figure 4a-c).

In the Primed Unfamiliar condition, an unfamiliar target was preceded by a prime of the same (Figure 4a and 4c, Experiment 1 and 3) or a strongly associated identity (unknown to the participants, Figure 4b, Experiment 2). In the Unprimed Unfamiliar condition, an unfamiliar target was preceded by an unrelated prime stimulus familiar to the participant (Figure 4).

Therefore, primes in each "unprimed" condition were always taken from the other familiarity category, i.e. familiar targets were preceded by unfamiliar primes and unfamiliar targets were preceded by familiar primes. Because of this, the familiarity of a prime was not predictive for the familiarity of the subsequent target.

Every experiment consisted of two blocks with 96 trials each. These were equally divided so that 24 trials were devoted to each of the four experimental conditions in each block and presented in random order. Participants were asked to provide 25 images per identity to ensure the researchers may exclude any photograph with insufficient quality or low face visibility if submitted by a participant. In Experiment 2, the extra image was utilised for the practice trial block.

The same image was never used twice as the target stimulus within a single block, since the present study aimed at minimizing picture repetition to measure neural responses during image-invariant identity recognition rather than picture recognition. The stimuli were presented using E-Prime (Version 2.0.10.92; www.pstnet.com).

Figure 3. Sample "ambient" familiar and unfamiliar stimuli for experiments 1-3. All photographs are used with the permission of the depicted individuals.

During each experimental session, participants were seated in an electrically shielded and sound-attenuated chamber with their heads in a chin rest at 100 cm from a monitor. They were instructed to remain focused on the screen and avoid any unnecessary movements to prevent EEG movement artifacts. The task was to press a button with their left or right index fingers to indicate whether the target face (in Experiment 3, the second face presented in each trial; in Experiment 1 and 2, the face presented after a name stimulus) was familiar (1) or unfamiliar (4) on a four-key keyboard. The participants were instructed to perform this familiarity judgement as rapidly and as accurately as possible. Each trial began with a green fixation cross presented on the screen for 1500ms. Then, a prime stimulus was shown for the duration of 200ms, followed by a red fixation cross present on the screen for 600ms, after which the target face was displayed for 1000ms (see Figure 4 for example trials).

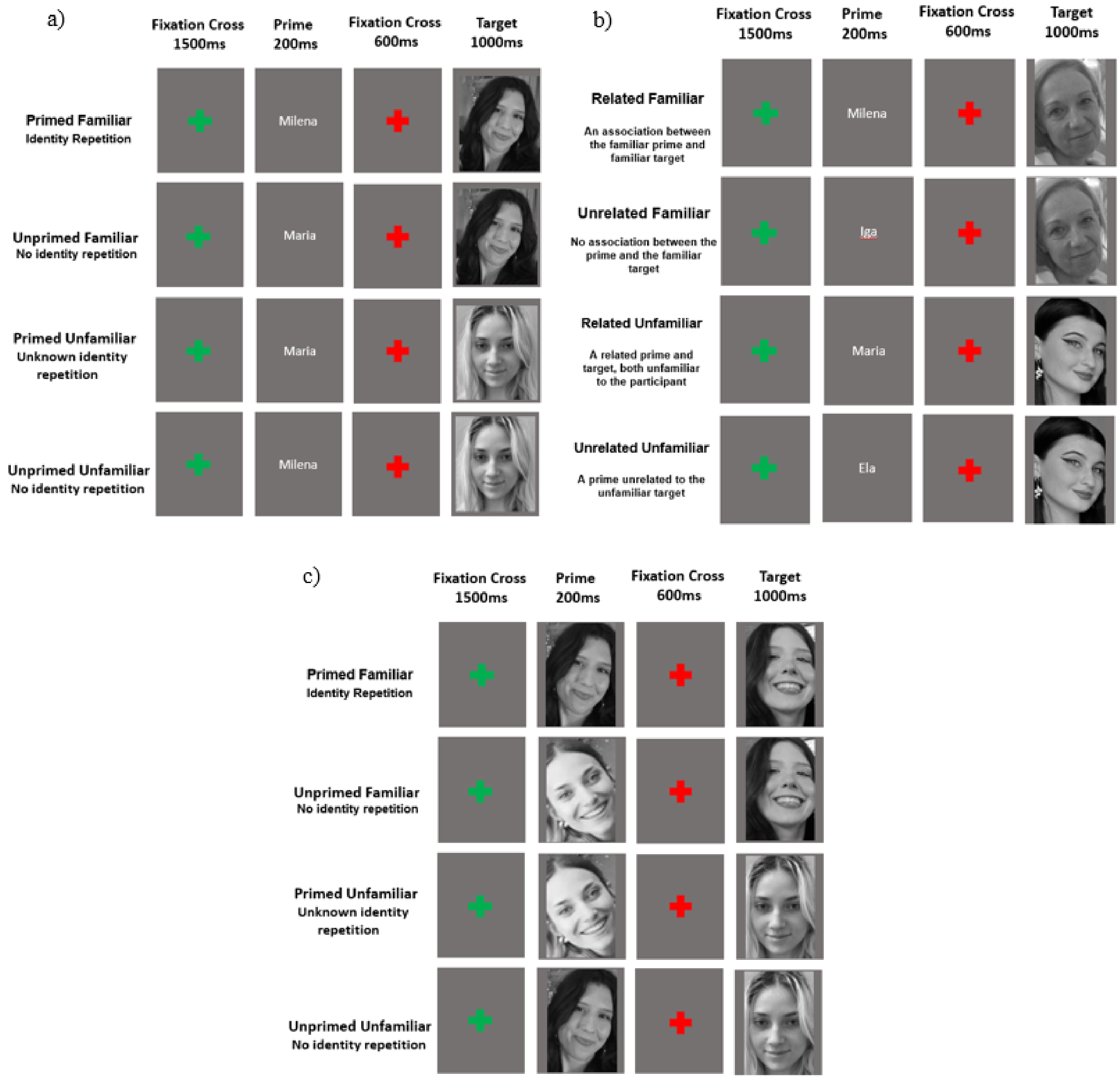

Figure 4. Sample trial structure of (a) Self-Priming/Experiment 1; (b) Associative Priming/ Experiment 2; (c) Repetition Priming/Experiment 3. Each experiment is explained in detail in the corresponding "Procedure" sections. All photographs are used with the permission of the individuals depicted.

2.3. EEG Recording and Analysis

During the experiments, 64-channel EEG was recorded from sintered Ag/Ag-Cl electrodes mounted in CW-1809 Waveguard caps (Eemagine; Berlin, Germany), using an ANT Neuro EEGo amp (ANT Neuro; Enschede, the Netherlands). EEG was recorded with a 1024 Hz sampling frequency from DC-120 Hz. A forehead electrode (AFz) served as ground and CPz was used as the recording reference. Recording sites corresponded to the 10-20 system, including the TP9/TP10 and P9/P10 ventral electrode positions specifically relevant to this study (see Figure 5). Blink artifacts were corrected using the BESA 6.3 Research software algorithm (Gräfelfing, Germany; Berg & Scherg, 1994). EEG was segmented from -50 to 1000ms relative to target onset with the first 100ms (-50 to 50ms; Zimmerman & Eimer, 2013) set as a baseline. A subsequent artifact rejection was conducted using the BESA 6.3 tools with an amplitude threshold of 100 μV, and a gradient criterion of 75 μV.

All remaining trials were filtered (0.1 to 40 Hz, zero-phase shift), re-calculated to the common average reference and averaged according to each experimental condition. The average number of accepted trials will be listed separately for each experiment. Resulting waveforms underwent ERP analysis. Consequently, mean amplitudes were calculated for 200-300ms (the N250 and the N250r), 300-400ms (N250 and N250r), 400-500ms (the SFE) and 500-600ms (the SFE) time windows at left and right hemispheric occipito-temporal electrodes, specifically at P9/P10 and TP9/TP10. The focus of the present analysis was determined prior to data analysis on the basis of previous research which finds the familiarity effects for faces reach their maximum at the occipito-temporal channels selected (Wiese et al., 2019b; Wiese et al., 2019c).

Statistical analysis of the ERP data was conducted using repeated-measures analyses of variance (ANOVAs). It is essential to note that beyond investigating ‘priming’ and ‘familiarity’ factors, the ANOVA included factors ‘electrode’, ‘hemisphere’ and ‘site’ which were incorporated for exploratory purposes rather than being central to the primary hypotheses. Because of this complexity, the error term from the ANOVA may not provide a sufficient estimate of variability for testing the specific a-priori hypotheses. Instead, paired-samples t-tests were used to directly test predictions concerning the priming and familiarity conditions, allowing for a more targeted examination of the hypothesised effects. This avoids unnecessary confounding variance from unrelated exploratory factors.

In addition, the ANOVA analysis was conducted separately for each time window rather than including a factor of ‘time window’ as this consistent with standard practice in literature (e.g. Wiese et al., 2024). While there exists a possibility of false conclusions regarding qualitative changes in ERPs over time, it increases the complexity of the model and would risk the appearance of higher-order interactions that would be problematic to interpret. It is generally advised to reduce the number of factors included in ANOVAs conducted in ERP research (Luck & Gaspelin, 2016) given the increasing risk of familywise error.

The design, hypotheses or analyses of the present experiments were not pre-registered.

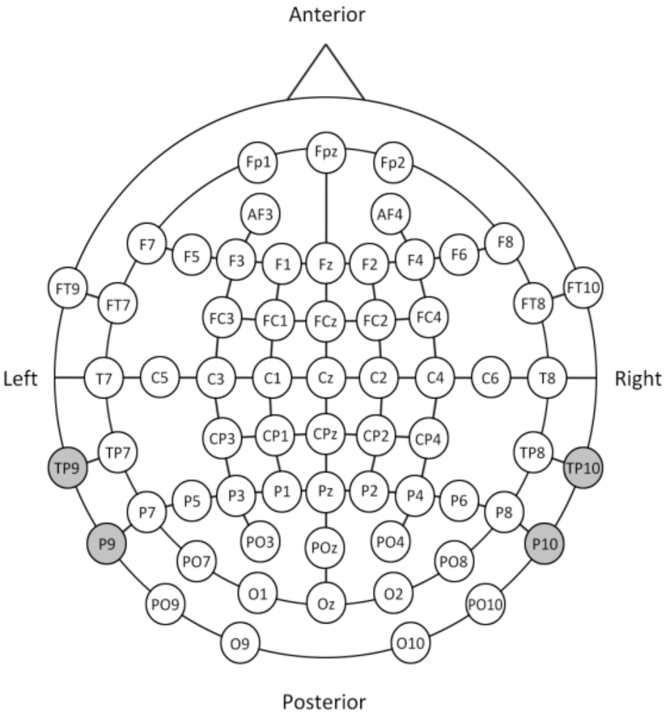

Figure 5. Layout of the EEG electrodes. The occipito-temporal recording electrodes particularly relevant in the present study (TP9/P9 and TP10/P10) are shaded in grey.

Chapter 3

Neural Underpinnings of Familiar Person Recognition

Evidence from the Influence of Self-Priming on the Sustained Familiarity Effect

3.1.Introduction

Experiment 1 tested whether immediate cross-domain repetition priming would significantly influence the Sustained Familiarity Effect detected in human ERPs to faces. Accordingly, we inquired whether the locus of the SFE is at the domain-general person representations (PINs) on which bottom-up input from any stimulus domain (e.g. FRUs or NRUs) converges (Burton et al., 1990; Wiese et al., 2017). In addition, the study assessed whether the self-priming effect is modulated by the prediction of the categorical response to the target (familiar/unfamiliar), which was examined with response priming using either congruent or incongruent primes (Schmidt et al., 2011; Friston, 2012; Amado et al., 2018).

When interacting with a new person in real-life settings, we gain perceptual experience with their face in tandem with rich identity-specific knowledge about the individual (Jenkins, 2011; Koca & Oriet, 2023; Schwartz & Yovel, 2019; Noad & Andrews, 2024). Recently, researchers found that both perceptual and conceptual processing of socially relevant faces may facilitate image-independent recognition of familiar people (Young & Burton, 2017; Schwartz & Yovel, 2019; Noad & Andrews, 2024). To gain a better understanding of this multifaceted ability, the present study will investigate this advantage of close familiarity during person recognition using self-priming. As detailed in Chapter 1.2, identity recognition is possible once a PIN receives sufficient activation from its corresponding domain-specific representation (e.g. the FRUs or NRUs) or the related domain-general units (SIUs; Burton et al., 1990; Carson & Burton, 2001). Seeing the names of familiar people should facilitate access to their domain-general representations and subsequent face recognition (Calder & Young, 1996) eliciting the well-established N400 effect (Pickering & Schweinberger, 2003).

Alternative explanations propose that the self-priming effect detected with this method (including a familiar/unfamiliar decision to the perceived target) may reflect predictive coding, where the neural activity changes depending on whether the prime is congruent with the expected target after processing the familiarity of both stimuli, which could be elicited with response priming (Schmidt et al., 2011). The influence of the prediction of a response to the target in this study would be seen for the processing of both unfamiliar *and* familiar targets, as any name prime should provide context significant for a subsequent familiarity decision (Olkkonen et al., 2017; Amado et al., 2018).

Moreover, EEG research has identified the N250 effect, providing evidence for a significant difference between how familiar and unfamiliar faces are processed (see 1.3.1., Gosling & Eimer, 2011; Wiese et al., 2019c). It is followed by the SFE which becomes significant at later ERP time windows (see 1.4.1). Recent research hypothesised the SFE reflects post-perceptual processing of familiar faces (Wiese et al., 2019b; Wiese et al., 2019c; Wiese et al., 2022b). However, it can be questioned whether this effect reflects access to *visual* representations of familiar faces, e.g. responding to faces associated with more visual experience (Wiese et al., 2022b), or is more conceptual, related to integration of *person knowledge* (Burton et al., 1990; Calder & Young, 1996; Schweinberger, 1996).

Therefore, Experiment 1 utilized self-priming to investigate the functional underpinnings of the SFE (Wiese et al., 2019c; Wiese et al., 2022b). Familiar and unfamiliar target faces were presented after a prime which could either be the same or a different ID as the target (Schweinberger et al., 1995). The introduction of a prime from a different stimulus domain than the target should have *no* influence on the difference between neural responses to familiar vs unfamiliar faces elicited in the N250 time window, since it has been associated with modality-specific processing of faces (Kaufmann et al., 2009; Zimmermann & Eimer, 2013; Wiese et al., 2019c). In turn, if the SFE is a post-perceptual effect reflecting the activation of *identity representations*, it should be modulated by self-priming. In this case, we hypothesize that the SFE will be diminished in trials where the prime and target represent a different person, in comparison to conditions involving cross-domain identity repetition. Moreover, if the self-priming effect and the N400 are modulated by the target familiarity category prediction, we expect that a mismatch between the response mapped to the prime and the target (familiar/unfamiliar) will have a significant influence on the ERP amplitudes elicited by familiar and unfamiliar faces.

3.2 Methodology

3.2.1 Participants

The sample size was determined based on Wiese et al. (Experiment 1, 2019c), where a power analysis using G*Power 3.1 (Faul et al., 2017) required N = 15 to find significantly more negative amplitudes to familiar faces relative to unfamiliar faces (two-tailed paired-samples t-test, dz. = 0.8, 1 – β = 0.8). To further increase power, we tested 20 Durham University undergraduate and postgraduate students (16 female, mean age = 21.1, *SD* = 1.18). A modified Edinburgh Handedness Inventory (Oldfield, 1971) found that 18 participants reported dominant right-handedness and two participants were left-handed (mean laterality quotient = 69.41, *SD* = 27.12 ; see Appendix A). All participants reported normal or corrected-to-normal vision, no scalp wounds, no known neurological disorders and none took any psychoactive medications at the time of the experiment. All participants provided written informed consent. Undergraduate psychology students who took part in the study were compensated with participant pool credit, while postgraduate student participants were compensated with Amazon vouchers. The experiment was approved by the ethics committee of the Durham University Psychology department.

3.2.2 Stimuli

Collection and preparation of stimuli for the Self-Priming experiment has been discussed in section 2.1 of the General Methods. In this experiment, participants were additionally required to supply the researcher with first names of the two familiar individuals.

3.2.3 Procedure

The procedure of the Self-Priming experiment has been described in section 2.2 of the General Methods. It is also essential to note that during this experiment, the prime stimulus was always a written name. Participants were shown personally familiar or unfamiliar faces preceded either by the name of the depicted person or a different name. Familiar primes always preceded unfamiliar targets in the Unfamiliar Unprimed condition (see Figure 4).

3.2.4 EEG recording and data analysis

A detailed description of the EEG recording, and the specific steps followed during data analysis are provided in section 2.3. Following EEG artifact rejection, the mean number of trials accepted from this experiment's recordings was 45.1 (SD = 4.85, min = 28) for the Primed Familiar condition, 45.65 (SD = 4.79, min = 28) for Unprimed Familiar condition, 45.75 (SD = 2.69, min = 34) for the Primed Unfamiliar and 45.55 (SD = 4.58, min = 29) for the Unprimed Unfamiliar condition.

3.3 Results

3.3.1 Performance

The reaction times (RT) and accuracy of participants (n = 19) when making familiarity judgements of the target face were measured for each experimental condition (Table 1, 2). One participant was excluded from this analysis as they have failed to indicate the familiarity of a target face in the 1000ms time window during which the target face was visible on the screen.

Reaction Times

Table 1.

The average reaction times (mean and standard deviation) for making an accurate familiarity decision for familiar and unfamiliar targets across conditions

	Familiar Faces			Unfamiliar Faces		
	Primed	Unprimed	Priming Effect	Primed	Unprimed	Priming Effect
M (ms)	486.04	539.57	53.54	519.67	524.63	4.97
SD	81.14	90.30	60.17	79.78	80.26	18.77

A repeated-measures ANOVA with factors target familiarity (familiar, unfamiliar) and priming (primed, unprimed) was conducted to investigate whether RTs significantly differed across the experimental conditions. There was no significant effect of target familiarity, $F(1, 18) = 2.12$, $p = .163$, $\eta^2_p = .105$, however, a significant main effect of priming was detected, $F(1, 18) = 16.31$, $p = .001$, $\eta^2_p = .475$. On average, primed target faces elicited faster RTs than unprimed targets. An interaction of familiarity by priming was also significant, $F(1, 18) = 11.33$, $p = .003$, $\eta^2_p = .386$.

These findings were followed-up using paired-samples t-tests. Before proceeding, it is important to highlight that significant interactions will be broken down using t-tests in the remaining parts of this submission despite relevant information being captured in the *F* statistic for the interaction. As mentioned on page 48, t-tests are deemed essential here, as these are the direct tests of my hypotheses. In addition, reporting Cohen's *d* is a valuable addition to my analysis, adding to the practical significance of my results – this measure of effect size is easier to interpret and is more relevant to my a-priori predictions than the η^2_p, which is sensitive to the number of factors and levels in my design (Lakens, 2013).

Thereof, first, it was determined that the priming effect was significantly different between the RTs to familiar and unfamiliar target faces, M_{diff}= 48.57, 95% CI [18.249, 78.895], $t(18) = 3.365$, $p = .003$, $d_z = .772$, 95% CI [.249, 1.279].

This difference was further examined by comparing the influence of identity repetition on the RTs for familiarity decisions of familiar and unfamiliar faces. When a target face was familiar to the participant, the time they took to make a familiarity judgement was significantly reduced by the presentation of a prime depicting that person's name, M_{diff}= 53.54, 95% CI [24.536, 82.539], $t(18) = 3.878$, $p = .001$, $d_z = .890$, 95% CI [.347, 1.415]. Conversely, priming did not impact the RTs for determining the familiarity of unfamiliar faces, M_{diff}= 4.97, 95% CI [-4.080, 14.011], $t(18) = 1.153$, $p = .264$.

Accuracy:

Table 2.

Average accuracy (mean and standard deviation) for making a familiarity decision for familiar and unfamiliar targets across conditions.

	Familiar Faces			Unfamiliar Faces		
	Primed	Unprimed	Priming Effect	Primed	Unprimed	Priming Effect
M	0.89	0.86	-0.03	0.87	0.89	0.01
SD	0.23	0.23	0.04	0.23	0.21	0.06

An ANOVA conducted on the participants' accuracy (Table 2) across experimental conditions did not detect a significant effect of familiarity, $F(1, 18) = 0.29$, $p = .595$, $\eta^2_p = .016$, or priming, $F(1, 18) = 0.71$, $p = .411$, $\eta^2_p = .038$. Again, a significant interaction of familiarity by priming was found, $F(1, 18) = 6.28$, $p = .022$, $\eta^2_p = .259$. Subsequent paired-samples t-tests revealed a significant difference between the priming effect in conditions where participants made familiarity decisions regarding familiar and unfamiliar targets, M_{diff}= -0.04, 95% CI [-.074, -.006], $t(18) = -2.505$, $p = .022$, $d_z = -.575$, 95% CI [-1.055, -.081].

This was further investigated by comparing accuracy of responses to primed and unprimed familiar targets. It was found that when participants saw a familiar face preceded by the person's name, they were on average more accurate in their familiarity judgements, M_{diff}= -0.03, 95% CI [-.044, -.008], $t(18) = -3.051$, $p = .007$, $d_z = -.700$, 95% CI [-1.196, -.189]. This finding was not replicated in conditions where the targets were unfamiliar, M_{diff}= 0.01, 95% CI [-.013, .041], $t(18) = 1.063$, $p = .302$.

Event-related potentials

The ERP results for Experiment 1 (self-priming) are illustrated in Figure 6 a-d. The familiarity and priming effects consistently showed occipito-temporal scalp distributions. A visual inspection of the grand-average ERPs in Figure 6a indicated that familiar target faces consistently elicited more negative amplitudes than unfamiliar faces. This difference started at approximately 200ms and peaked after 350ms (Figure 6b). The effect was reduced but remained significant beyond 400ms.

There was a clear influence of priming, with consistently more negative amplitudes for unprimed than primed familiar and unfamiliar faces from approximately 400ms (Figure 6a and 6d). Additionally, a stronger familiarity effect was detected over the right hemisphere in the primed condition (300-400ms; Figure 6c). These findings were largely supported by statistical analyses.

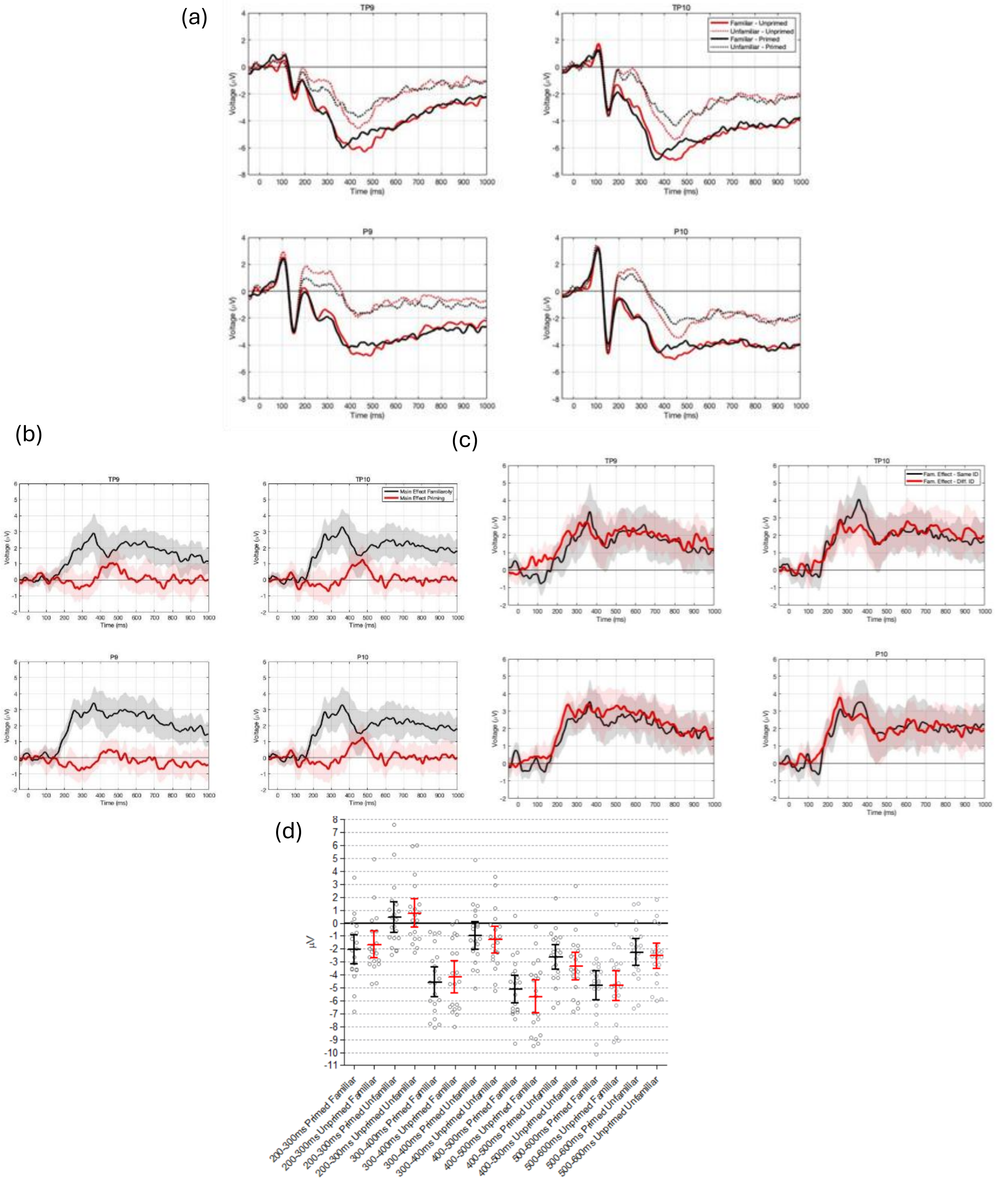

Figure 6. Results for Experiment 1 (Self-Priming). (a) Grand average event-related potentials for primed/unprimed familiar and unfamiliar faces at occipito-temporal electrodes over the left and right hemisphere. (b) Mean (+/−95% CI) difference curves for the familiarity effect (unfamiliar – familiar) and priming effect (unprimed – primed). (c) Mean (+/- 95% CI) difference curves for the familiarity effect in the primed and unprimed conditions separately. (d) Mean (+/- 95% CI) and individual responses to each priming and familiarity condition displayed for 100ms time windows from 200-600 ms.

200-300:

A repeated-measures ANOVA in the N250 tame frame (200-300ms) was conducted with within-subject factors of hemisphere (left, right), site (TP, P), familiarity (familiar, unfamiliar) and priming (primed, unprimed). It revealed a significant main effect of site, $F(1, 19) = 20.771$, $p < .001$, $\eta^2_p = .522$, and familiarity, $F(1, 19) = 95.985$, $p < .001$, $\eta^2_p = .835$, with more negative amplitudes for familiar than unfamiliar faces. This is consistent with prior expectations, depicting a clear N250 familiarity effect. Subsequent paired-samples t-tests (Table 3) revealed that this familiarity effect was significant in both primed and unprimed conditions.

Significant interactions of site by familiarity, $F(1, 19) = 4.841$, $p = .040$, $\eta^2_p = .203$ and hemisphere by familiarity, $F(1, 19) = 7.989$, $p = .011$, $\eta^2_p = .296$, were found. Moreover, a main effect of priming was detected, $F(1, 19) = 4.672$, $p = .044$, $\eta^2_p = .197$, with more negative amplitudes for primed than unprimed faces. However, the interaction of familiarity by priming was not significant, $F(1, 19) = .022$, $p = .882$, $\eta^2_p = .001$.

Even though the interaction of priming with familiarity was not significant, the priming effect was tested separately for familiar and unfamiliar faces. It is important to note that the difference between unprimed and primed faces was not significant in either of the familiarity conditions. While a visual inspection of Figure 6 revealed the priming effect was quite prominent for unfamiliar faces, statistical analysis detected it had only a smaller p-value and a larger effect size than the effect of priming on the amplitudes elicited by familiar faces (Table 3).

300-400:

Further analysis in the late N250 (300-400 ms) time window also yielded a significant main effect of site, $F(1, 19) = 44.973$, $p < .001$, $\eta^2_p = .703$ and familiarity, $F(1, 19) = 67.720$, $p < .001$, $\eta^2_p = .781$, with familiar faces eliciting more negative amplitudes than unfamiliar faces.

Moreover, a significant interaction of hemisphere by familiarity was found, $F(1, 19) = 4.824$, $p = .041$, $\eta^2_p = .202$. We did not detect a significant main effect of priming, $F(1, 19) = .041$, $p = .842$, $\eta^2_p = .002$. However, there was a significant interaction of hemisphere by priming, $F(1, 19) = 12.089$, $p = .003$, $\eta^2_p = .389$.

Follow-up paired samples t-tests revealed that there was no significant difference between primed and unprimed **familiar** targets at the right hemispheric electrodes, M_{diff}= -.308 µV, 95% [-.875, .259], $t(19) = -1.137$, $p = .270$. However, the unprimed unfamiliar condition elicited significantly more negative amplitudes than the primed unfamiliar condition, $M_{diff}=$ .717 µV, 95% [.258, 1.176], $t(19) = 3.269$, $p = .004$, $d_z = .731$, 95% CI [.228, 1.219], over the right hemisphere.

Over the left hemisphere there was no significant difference between the primed and unprimed conditions for both familiar, $M_{diff}=$ .922 µV, 95% [-.218, 2.061], $t(19) = 1.693$, $p =$ .107, and unfamiliar targets, $M_{diff}=$ .110 µV, 95% [- 1.014, 1.234], $t(19) = 0.205$, $p = .840$.

A subsequent comparison revealed that the familiarity effect significantly differed between the two priming conditions (see Table 3). This difference was significant over the right hemisphere, $M_{diff}=$ 1.025 µV, 95% [.224, 1.826], $t(19) = 2.677$, $p = .015$, $d_z = .599$, 95% CI [.115, 1.069], but not over the left hemisphere, $M_{diff}=$ 0.406 µV, 95% [-0.563, 1.375], $t(19) =$ 0.877, $p = .196$.

Most notably, the familiarity effect was larger in the identity repetition condition than in the non-repetition condition. This indicates that the difference between the amplitudes elicited by unfamiliar and familiar targets was most prominent when the identity of the face was primed by the same person's name.

400-500:

An ANOVA in the SFE time window (400-500ms) again revealed a significant main effect of site, $F(1, 19) = 41.867$, $p < .001$, $\eta^2_p = .688$ and familiarity, $F(1, 19) = 23.947$, $p < .001$, $\eta^2_p =$ .558, with more negative-going amplitudes for familiar faces. The interaction of site by hemisphere x familiarity was significant as well, $F(1, 19) = 5.511$, $p = .030$, $\eta^2_p = .225$.

Moreover, a significant main effect of priming was detected, $F(1, 19) = 7.507$, $p = .013$, $\eta^2_p =$ .283, with more negative amplitudes elicited by unprimed relative to primed faces.

Although the interaction of priming with familiarity was not significant, $F(1, 19) = 0.271$, $p =$ .608, $\eta^2_p = .014$, the priming effects were tested separately for familiar and unfamiliar faces. It revealed that this difference was significant when participants were seeing unfamiliar targets, while only a trend was observed for familiar targets (Table 3). Finally, a significant interaction of site by priming was detected, $F(1, 19) = 5.589$, $p = .029$, $\eta^2_p = .227$.

500-600:

A further ANOVA in the late SFE time window (500-600ms) yielded a significant effect of site, *F*(1, 19) = 15.285, *p* = .001, η^2_p = .446, hemisphere, *F*(1, 19) = 4.472, *p* = .048, η^2_p = .191 and familiarity, *F*(1, 19) = 54.023, *p* < .001, η^2_p = .740, as well as a significant interaction of site by hemisphere x familiarity, *F*(1, 19) = 4.560, *p* = .046, η^2_p = .194. The main effect of priming was no longer significant, *F*(1, 19) = .964, *p* = .339, η^2_p = .048. A subsequent comparison revealed that the familiarity effect was consistently significant in both of the priming conditions (Table 3).

Table 3.

Paired-samples comparisons of the ERP amplitudes in the N250 and SFE time windows elicited by different priming and familiarity conditions.

	M_{diff} (μV)	95% *CI*	*t*(19)	*p*	d_z	95% *CI*
200-300ms						
Familiar Target - R vs NR	0.364	-0.248, 0.976,	1.246	.228	0.279	-0.172, 0.722,
Unfamiliar Target - R vs NR	0.311	-0.030, 0.652	1.909	.072	0.427	-0.037, 0.880
Familiar vs Unfamiliar - R	2.474	1.823, 3.125	7.950	<.001	1.778	1.057, 2.481
Familiar vs Unfamiliar - NR	2.421	1.789, 3.053	8.018	<.001	1.793	1.068, 2.499
Fam. Effect R vs Fam. Effect NR	0.053	-0.691, 0.797	0.150	.882	0.034	-0.405, 0.471
300-400ms						
Familiar Target - R vs NR	0.384	-0.138, 0.907	1.539	.140	0.344	-0.112, 0.792
Unfamiliar Target - R vs NR	0.331	-0.147, 0.809	1.451	.163	0.324	-0.130, 0.770
Familiar vs Unfamiliar - R	3.594	2.677, 4.510	8.205	<.001	1.835	1.100, 2.552
Familiar vs Unfamiliar - NR	2.878	1.949, 3.807	6.484	<.001	1.450	0.807, 2.074
Fam. Effect R vs Fam. Effect NR	0.793	0.058, 1.529	2.257	.036	0.505	0.032, 0.965
400-500ms						
Familiar Target - R vs NR	0.569	-0.069, 1.207	1.865	.078	0.417	-0.046, 0.870
Unfamiliar Target - R vs NR	0.719	0.209, 1.229	2.953	.008	0.660	0.168, 1.139

Familiar vs Unfamiliar - R	2.480	1.423, 3.537	4.910	<.001	1.098	0.530, 1.648
Familiar vs Unfamiliar - NR	2.329	1.243, 3.416	4.486	<.001	1.003	0.454, 1.535
Fam. Effect R vs Fam. Effect NR	0.151	-0.455, 0.756	0.521	.608	0.116	-0.325, 0.555
500-600ms						
Familiar Target - R vs NR	0.040	-0.453, 0.533	0.169	.868	0.038	-0.401, 0.476
Unfamiliar Target - R vs NR	0.283	-0.220, 0.787	1.177	.254	0.263	-0.186, 0.706
Familiar vs Unfamiliar - R	2.549	1.743, 3.354	6.623	<.001	1.481	0.831, 2.112
Familiar vs Unfamiliar - NR	2.305	1.553, 3.058	6.413	<.001	1.434	0.795, 2.055
Fam. Effect R vs Fam. Effect NR	0.244	-0.477, 0.964	0.708	.488	0.158	-0.285, 0.597

3.4 Discussion

The aim of Experiment 1 was to test the influence of priming on the recognition of personally familiar and unfamiliar *people* from their faces, preceded either by the name of the same or of a different (unfamiliar) person. A key goal of the study was to examine whether the SFE reflects facilitated access to domain-general person representations, which can be modulated by self-priming (Calder & Young, 1996; Ellis et al., 1996). Importantly, we tested whether ERP priming effects and the SFE would additionally vary depending on whether the prime and target matched on their response category (familiar/unfamiliar) to investigate if predictions related to the information provided by a prime have a significant influence on this stage of face recognition (Bruce, 1983; Wiese & Schweinberger, 2011).

3.4.1 Behavioural findings

RTs for making a familiarity decision (familiar/not familiar) to personally familiar faces were significantly faster when primed by the same person's name, rather than the name of a stranger. Priming had no significant impact on the RTs to unfamiliar faces preceded either by a familiar or an unfamiliar name. This is in-line with previous behavioural research, where short-lag repetition priming was found to successfully facilitate person recognition via primes from different stimulus domains than the target, specifically when both were depicting the same identity (Young et al., 1994; Calder & Young, 1996; Calder et al., 1996). Experiment 4 in Young et al. (1994) as well as Experiment 1 in Calder & Young (1996) utilized famous *names* as targets and found similar results to the present study - the familiarity decision to a familiar person's name was made faster if it was preceded by their face. This was again found for target *faces* preceded by the same celebrity's name in the second experiment from Calder & Young (1996) and in the second experiment conducted by Wiese et al. (2017).

The present study used a longer inter-stimulus interval (600ms) and SOA (800ms) than previous research (e.g. 250ms in Young et al., 1994 and Calder & Young, 1996), which could suggest a potential influence of expectancy-based strategic processing, where a participant would attempt to consciously predict whether the stimulus following the prime will be familiar or not (Becker, 1980; Brennen & Bruce, 1991; Wiese, 2011). This phenomenon was previously observed at SOAs longer than 400ms in research examining priming for a lexical decision (e.g. *is the target a word or a nonword?*) to targets which could be semantically related or unrelated to the prime and therefore either expected or unexpected by the participant (Neely, 1977; Wiese, 2011). This should be considered before making concrete conclusions about the role of facilitated access to domain-general person representations in eliciting faster RTs to primed familiar targets.

Still, in this case, it can be initially argued that Experiment 1 measured the influence of *identity repetition,* as significantly faster RTs were found only for primed familiar faces. There was no significant influence of response priming, which would be observed for the RTs to both familiar and unfamiliar target stimuli, with slower RTs in trials with incongruent primes, as a target would have been linked with the same response as the given prime (i.e. familiar/unfamiliar button press; Schmidt et al., 2011). The following analysis of ERP results will inform us whether predictive coding could have influenced these outcomes of research examining the neural correlates of priming. Still, the behavioural results of this experiment align with prior research and it appears that immediate identity repetition can successfully influence how quickly a *person* is recognized as familiar.

3.4.2 ERP findings

As predicted, a clear N250 familiarity effect (the difference between amplitudes elicited by unfamiliar and familiar faces from 200-400ms; Wiese et al., 2019c) was detected, which is consistent with prior ERP findings measuring neural responses elicited during explicit face recognition (e.g. determining whether a face is familiar or not; Gosling & Eimer, 2011). Experiment 1 and related research show a clear distinction between how personally familiar and unfamiliar faces are processed which emerges around 200ms after stimulus onset over the occipito-temporal brain areas (Wiese et al., 2019c). The early N250 (200-300ms) coincided with a main effect of priming, however, separate tests for familiar and unfamiliar targets did not reveal significant priming effects. This suggests that the neural responses to familiar and unfamiliar faces are not significantly regulated by cross-domain priming in this time frame. Consequently, as defined in the Introduction, it likely reflects the access to the image-independent and long-term visual representations of personally familiar faces which are unavailable for unfamiliar faces (e.g. FRUs; Bruce & Young, 1986; Gosling & Eimer, 2011; Wiese et al., 2019b; Wiese et al., 2022b). These are domain-sensitive, which is why the corresponding waveforms have not been modulated by cross-domain priming (Calder & Young, 1996; Burton et al., 1990).

Nonetheless, the analysis of the later N250 time window (300-400ms) revealed that the familiarity effect was significantly larger in the identity repetition than in the non-repetition condition, predominately over the right hemisphere (see Figure 6c). The familiarity effect peaked at around 350ms (see Figure 6b), which is notably earlier than found by previous research in the field, as it normally reaches its maximum in the SFE time window (400-600ms; Wiese et al., 2019c; Wiese et al., 2022b). The post hoc analysis of this unexpected finding suggests that while the early N250 is domain-selective, the familiarity effect observed in 300-400ms potentially reflects the access to domain-general representations of familiar individuals via bottom-up input (i.e. the name prime), as it has been influenced by priming. This contradiction with past research will be investigated further in Experiment 2 (cross-domain priming) and 3 (within-domain priming).

Importantly, a clear SFE has also been found in the present study at 400-600ms, as expected by the pre-established hypothesis. However, its strength was notably reduced in comparison to the values obtained by relatively recent research, as the difference between the ERP amplitudes elicited by personally familiar and unfamiliar faces was approximately 2.5 μV, rather than the common average of around 4 μV (Wiese et al., 2019c; Wiese et al., 2022a; Wiese et al., 2023). The familiarity effect clearly diminished from ~400 to 500ms relative to the previous time window. This is illustrated by a visual inspection of Figure 6b and a reduced effect size of the main familiarity effect in the 400-500ms time window ($\eta^2_p = .558$) when compared to the 300-400ms time window ($\eta^2_p = .781$). Since these findings are contradictory to research which did not incorporate cross-domain repetition priming as an experimental manipulation when comparing the ERPs elicited by familiar and unfamiliar faces, the reduced SFE could potentially be attributed to the coinciding priming effect, which will be analysed in more detail in the paragraphs below.

The anticipated N400 effect was not detected, as more negative-going waveforms were found for the unprimed than the primed condition, which is in the opposite direction than expected over the TP/P electrodes selected for this analysis (Figure 6; Pickering & Schweinberger, 2003). Still, a significant difference between the ERP amplitudes elicited by unprimed and primed *unfamiliar* faces was detected from 400-500ms. Given these findings, the results of Experiment 1 can initially support the hypothesis emphasising the role of predictive coding in eliciting the difference between the ERP correlates of cross-domain repetition priming, which can be identified as a P3-like effect in this post hoc analysis (see below; Polich, 2007).

Initially, a potential influence of strategic processing on the cross-domain repetition priming effect was noted by Pickering & Schweinberger (2003) who used a relatively long SOA of 1.8s during their procedure, however, its influence on the N250r and the N400 was deemed negligible. The researchers did not consider whether the more automatic prediction of the upcoming target category could have influenced their findings. In turn, Jemel et al. (2005) found that self-priming did not modulate the ERP amplitudes elicited by unfamiliar faces, which contradicts the findings of the present study. However, in Jemel et al. (2005), familiar faces could be preceded by *same person* (primed) *neutral* (an empty white oval)*,* or *unrelated* (i.e. unprimed, a different familiar celebrity) primes, while unfamiliar targets could be preceded by *same person's face, neutral,* or *unfamiliar name* primes. Therefore, both familiar and unfamiliar primes in the unprimed trials (or unrelated, a different prime/target identity) were highly informative of the familiarity response required to each subsequent target, allowing for reliable predictions about it to be made, which likely influenced the experiment's behavioural results. Consequently, no primes provided participants' cognitive system with mismatching context which could lead to a wrong category prediction (e.g. familiar prime before an unfamiliar target) in the conditions measuring participants' responses to unprimed conditions, which contrasts with the methodology used in the current research.

Here, in 50% of the trials, there was a prime-target category (i.e. whether these are familiar or not) match, and in the remaining trials the two did not match. This was necessary to ensure that the familiarity of the target could not always be predicted from the prime. In this case, participants attempting to consciously predict the upcoming target would not be a productive strategy, since there was only a 50/50 chance at a correct guess in each trial. Therefore, this allowed us to examine whether the more automatic predictive coding resulting from response priming had influenced the behavioural results and the ERP waveforms measured (Amado et al., 2018). It can be hypothesized that the a P3-like effect of priming appearing relatively early and continuing until 500ms reflects a potential role of predictive coding and context-updating, which will be examined in the following paragraphs.

The P3 is a positive ERP deflection which peaks at around 300ms (from 250-500ms, depending on stimuli and task used; Polich, 2007) over centro-parietal electrodes, often modulated by the degree of certainty regarding the probability of an incoming stimulus (Sutton et al., 1965; Nieuwenhuis et al., 2011; Barry et al., 2016; Rosenfeld, 2019). Researchers additionally differentiate between the P3a and the P3b subcomponents. The P3a occurs at ~250-280ms, has a shorter peak latency and is generally elicited by infrequent/rare stimuli (Squires et al., 1975; Polich, 2007, Barry et al., 2016). The P3b is detected later (300-600ms) and elicited during the processing of task-relevant *target* stimuli (e.g. in an oddball task, see below; Polich, 2007). The *context-updating* theory proposes that the P3b reflects the updating of working memory (WM) when our cognitive system is exposed to an unexpected stimulus, detecting any change or incongruence between the active context and a stimulus which is relevant for the performed task (Squires et al., 1975; Karis et al., 1984; Polich, 2007). This has been generally examined by manipulating stimulus predictability with “oddball” tasks, where low-frequency target stimuli are presented in a sequence of frequent non-target stimuli (Duncan-Johnson & Donchin, 1977; Gonsalvez & Polich, 2002). Higher P3 amplitudes have been found for the detected unexpected/rare targets, rather than non-targets (Donchin & Coles, 1988; Ritter et al., 1999; Reed et al., 2022).

More specifically, van Vliet et al. (2014) investigated the influence of a speeded *button press* response task on the ERPs and MRPs (motor-related potentials) elicited with semantic priming. Word pairs were presented to the participants, requiring them to quickly decide whether or not these are strongly associated based on their meaning. Importantly, the study showed that having participants quickly respond to targets after processing their semantic link to the given prime elicited a response-related P3 effect. Researchers argued it overlapped (in latency and topography) with and likely contaminated the expected N400 (evoked by the stimulus, not the response to it; van Vliet et al., 2014). Similar results could have been detected in the present study, however, the prime stimuli used in this research were additionally informative of the potential response to the target, possibly engaging related predictive mechanisms (Amado et al., 2018).

Therefore, the priming effect detected in Experiment 1 for unfamiliar *and* familiar faces could be attributed to an unanticipated prime/target response mismatch. The prime provided the participant's WM with context and was mapped to a specific familiarity response (Polich, 2007; Kiesel et al., 2008; Schmidt et al., 2011), which had to be updated after the presentation of an unrelated target for it to be explicitly judged on its familiarity. The face was task-relevant, which has been previously associated with an additionally enhanced P3b amplitude in comparison to irrelevant targets at later ERP time points (the P3b; Castro & Díaz, 2001; Rosenfeld, 2019; Reed et al., 2022). The issue with this interpretation may be the fact the influence priming had on the amplitudes elicited by *familiar* faces in the P3 time window was not statistically significant, even though half of the trials presented participants with *unfamiliar* names which did not match the familiar target faces. This can be rationalised by highlighting how unfamiliar names might have provided participants' cognitive system with less meaningful context for target processing, perhaps leading to a weaker ERP deflection if it did not match the incoming stimulus category.

Consequently, the diminished SFE relative to previous studies could be associated with the cognitive load required by the processing of the target category in relation to the context provided by the prime. As argued by past research, the SFE is sensitive to additional tasks occupying the participant's attention (e.g. Wiese et al., 2019b). Although the N250 was reliably detected, the cognitive processes associated with the SFE may have been interfered with by the predictive coding mechanisms involved in cross-domain repetition priming. Thus, while it is likely a post-perceptual process, it remains unclear whether the SFE reflects the retrieval of *person-specific knowledge* or the preparation for a potential interaction with the environment (Wiese et al., 2022b; Wiese et al., 2023).

The main interpretation of the present findings is that the familiar prime has provided sufficient activation to the related domain-general PIN, moving it closer to the threshold required for *person* recognition through the bottom-up input from NIUs (Burton et al., 1990), as reflected by the significant facilitation of recognition by cross-modality priming in the RT and accuracy data, together with a larger familiarity effect in the identity repetition condition found from 300-400ms. This research additionally distinguished between a domain-specific (200-300ms) and a domain-general (300-400ms) stage of processing within the pre-established N250 familiarity effect time window. Furthermore, context-updating and prime/target familiarity category processing may require similar cognitive resources as the SFE, informing us about its functional underpinnings. It will be possible to define these in more detail once the results of Experiment 2 are analysed, providing an additional lens for this interpretation based on the outcomes of domain-general *associative priming* during familiar person recognition.

Chapter 4

Neural Underpinnings of Familiar Person Recognition

Evidence from the Impact of Associative Priming on the Sustained Familiarity Effect

4.1 Introduction

Experiment 2 investigated whether the N250 or the SFE are influenced by the top-down activation of domain-general person representations via “semantic information units” (Burton et al., 1990) elicited with cross-domain associative priming, where participants were presented with associatively related or unrelated prime-target pairs. The potential influence of the prediction of an unfamiliar or familiar categorical response to the target on the N400 and the SFE was addressed further (see Chapter 3).

Relatively recent perspectives in the field of face recognition have emphasised the importance of the degree of familiarity we hold with a face in how it is processed (e.g. Clutterbuck & Johnson, 2005; Ramon & Gobbini, 2018; Wiese et al., 2022b). Our proficiency with familiar face recognition has been ascribed to the perceptual experience we have with a face (e.g. Andrews et al., 2015; Ritchie & Burton, 2017; Koca & Oriet, 2023), together with the *person knowledge* we possess about the recognized individual. Activating it should facilitate face recognition via top-down links (Burton et al., 1990; Leibenluft et al., 2004; Gobbini & Haxby, 2007; Ramon & Gobbini, 2018). As established in Chapter 3.1, the acquisition of substantial perceptual experience with previously unknown people alongside relevant conceptual information tends to significantly improve the participants’ performance when recognizing the newly learned faces (Schwartz & Yovel, 2016; Schwartz & Yovel, 2019; Noad & Andrews, 2024). However, experimental learning paradigms may not capture the real-life complexity underlying the recognition of people we have repeatedly encountered and interacted with in natural settings, where our familiarity with someone may range from weak to close and personally meaningful (e.g. a parent or a close friend; Idson & Mischel, 2001; Schwartz & Yovel, 2019; Wiese et al., 2019c).

A substantial degree of personal familiarity with a face has been associated with activity in brain areas responsible for processing of person-related information, e.g. social/emotional cognition (see Chapter 1.4.; Gobbini et al., 2004; Leibenluft et al., 2004; Visconti di Oleggio Castello et al., 2021; Wiese et al., 2019c). Experiment 1 and prior EEG research uncovered a significant and extended difference between the ERP amplitudes elicited by personally familiar vs unfamiliar faces from approximately 200 to 600ms after stimulus onset (Wiese et al., 2019c). Although the N250 familiarity effect (see Chapter 1.3) has previously been attributed to processing differences between known and unknown faces dependent on whether these are associated with a long-term visual memory representation (Gosling & Eimer, 2011; Huang et al., 2017), the subsequent SFE was associated with the post-perceptual integration of person knowledge we associate with the familiar face (Wiese et al., 2022b). However, more recent research found that the SFE is more likely to reflect the preparation for a potential interaction with *any* personally familiar item, rather than a familiar person, which poses some issues for the earlier hypotheses (Wiese et al., 2023).

Experiment 1 (see Chapter 3) found that the magnitude of the ERP familiarity effect was influenced by cross-domain priming from 300-400ms over the right hemisphere, showing identity repetition may modulate the recognition of a personally known faces in this time range. This suggests that the well-established N250 effect becomes domain-general earlier than expected, which is a post hoc interpretation that requires further investigation in Experiment 2. In addition, P3-like effects have been detected for familiar and unfamiliar targets, whilst the magnitude of the SFE was notably reduced in comparison to prior research (e.g. Wiese et al., 2019b; Wiese et al., 2019c). Therefore, the potential role of predicting the categorical response to the target in producing the ERP components elicited during cross-domain priming and its potential impact on the SFE should be explored further (Polich, 2007; Steinhauer et al., 2017). As such, even though initial ERP findings identified the SFE as a promising cognitive locus of post-perceptual processing of *identity-related information* for person recognition (Wiese et al., 2022b), this conclusion has not yet been fully supported by empirical evidence.

Therefore, Experiment 2 used cross-domain associative priming (discussed in Chapter 1.5.5; Young et al., 1988; Stone et al., 2008; Wiese & Schweinberger, 2015) to localize the SFE at a specific post-perceptual processing level involving the integration of *person knowledge* following familiar face recognition (Burton et al., 1990; Ramon & Gobbini, 2018). If the SFE is related to higher-level identity processing, we expect it to diminish in conditions where the prime and target are not associated with each other (e.g. an unfamiliar name followed by the face of the participant's mom). Additionally, the results of Experiment 1 will be followed-up, investigating whether the introduction of a familiar or unfamiliar name prime before an associated or an unrelated face serves as significant context for predictive coding, eliciting a corresponding effect when the prime is not closely related (i.e. via visual co-occurrence or semantic association; Wiese & Schweinberger, 2015) to the presented target face (Steinhauer et al., 2017; Amado et al., 2018).

4.2. Methodology

4.2.1 Participants

We tested 20 Durham university undergraduate and postgraduate students (18 female, mean age = 21.35, *SD* = 2.55). 18 participants reported dominant right-handedness, 1 participant was left-handed, and 1 participant was ambidextrous (mean laterality quotient = 74.21, *SD* = 36.21; see Appendix C) according to the modified version of the Edinburgh Handedness Inventory (Oldfield, 1971).

The compensation, exclusion, inclusion criteria and rules relating to obtaining participant consent and ethical approval remained the same as in Experiment 1. This experiment was also approved by the ethics committee of the Durham University Psychology department.

4.2.2 Stimuli

The stimuli utilised during the Associative Priming experiment have been described in the 2.1 section of the General Methods. Moreover, an additional requirement for participation in Experiment 3 was for the participants to provide first names and 25 different images each of two personally familiar people who are closely related to each other (e.g. two family members or two close friends from the same friend group). This was to ensure the participant holds a strong associative connection between the two familiar individuals whose faces were presented during the experiment (see Experiment 3 in Wiese et al., 2017).

4.2.3 Procedure

The general procedure of the experiments has been described in section 2.2 of the General Methods. Additionally, during the Associative Priming experiment participants viewed personally familiar or unfamiliar faces preceded either by the name of a highly associated (i.e. primed) or an unrelated (unprimed) person. Prime and target were never the same person. Therefore, the four experimental conditions were Primed Familiar, Unprimed Familiar, Primed Unfamiliar and Unprimed Unfamiliar (see Figure 4b).

An unfamiliar target was always preceded by a name familiar to the participant. Given the more demanding nature of this design, a short practice block (16 trials) was incorporated into the procedure as a way for participants to familiarize themselves with the task.

4.2.4 EEG recording and data analysis

A detailed description of the EEG recording, and the subsequent steps for statistical analysis were provided in section 2.3. Following the EEG artifact rejection, the average number of trials was 46.5 (SD = 2.69, min = 36) for the Primed Familiar condition, 46.35 (SD = 2.33, min = 38) for Unprimed Familiar condition, 45.6 (SD = 3.04, min = 39) for Primed Unfamiliar and 45.8 (SD = 2.46, min = 41) for the Unprimed Unfamiliar condition.

4.3 Results

The reaction times (RT) and accuracy of participants (n = 20) when making familiarity judgements of the target face were measured for each experimental condition (Table 4 and 5).

4.3.1 Behavioural findings

Reaction Times

Table 4.

Average reaction times (mean and standard deviation) for making accurate familiarity decisions for familiar and unfamiliar targets across conditions

	Familiar Faces			Unfamiliar Faces		
	Primed	Unprimed	Priming Effect	Primed	Unprimed	Priming Effect
M (ms)	475.29	487.56	12.27	479.30	482.63	3.33
SD	47.92	46.62	17.41	38.43	39.81	10.91

A repeated-measures ANOVA with factors familiarity (familiar, unfamiliar) and priming (primed, unprimed) was conducted to compare the RTs across the experimental conditions. No significant effect of familiarity was found, $F(1, 19) = .004$, $p = .948$, $\eta^2_p < .001$. However, a significant main effect of priming was detected, *F*(1, 18) = 11.82, *p* = .003, η^2_p = .384. There was no significant interaction of familiarity by priming, *F*(1, 18) = 3.69, *p* = .070, η^2_p = .163.

Even though the interaction did not reach significance, these findings were further investigated using paired-samples t-tests. There was no significant difference between the priming effect elicited by presenting either related or unrelated familiar and unfamiliar face-name pairs, M_{diff}= 8.93, 95% CI [-.799, 18.668], *t*(19) = 1.921, *p* = .070. Still, participants were significantly faster to make familiarity judgements when familiar faces were preceded by an associated person's name, M_{diff}= 12.27, 95% CI [4.117, 20.414], *t*(19) = 3.151, *p* = .005, d_z = .704, 95% CI [.206, 1.189]. This difference in RTs was not significant when participants viewed unfamiliar face targets, M_{diff}= 3.33, 95% CI [-1.773, 8.435], *t*(19) = 1.366, *p* = .188.

Priming unfamiliar faces resulted in slightly slower responses to the target face compared to priming of familiar faces, but this difference was not statistically significant, M_{diff} = 4.01, [-19.975, 11.959], *t*(19) = 0.525, *p* = .605. In turn, mean RTs (see Table 4) seem slower for unprimed familiar than unfamiliar faces, but this difference was not statistically significant, M_{diff} = 4.93, [-9.690, 19.543], *t*(19) = 0.705, *p* = .489.

Accuracy

Table 5.

Average accuracies (mean and standard deviation) for making familiarity decisions for familiar and unfamiliar targets across conditions.

	Familiar Faces			Unfamiliar Faces		
	Primed	Unprimed	Priming Effect	Primed	Unprimed	Priming Effect
M	0.94	0.93	-0.01	0.95	0.95	0.00
SD	0.06	0.08	0.04	0.06	0.06	0.03

An ANOVA was conducted to test the differences between the accuracy of familiarity judgements across all priming and familiarity conditions. There was no significant effect of familiarity, *F*(1, 19) = 1.45, *p* = .243, η^2_p = .071 or priming, *F*(1, 19) = 0.12, *p* = .738, η^2_p =

.006. The interaction of priming by familiarity was also insignificant, $F(1, 19) = 0.43$, $p = .521$, $\eta^2_p = .022$.

Event-related potentials

The ERP results for Experiment 3/Associative Priming are illustrated in Figure 7 a-e. The familiarity and priming effects consistently showed occipito-temporal scalp distributions. A visual inspection of the recorded grand-average ERPs (Figure 7a) found that familiar faces consistently elicit more negative waveforms than unfamiliar faces, which is in line with the previous findings of this thesis. This effect started at approximately 200ms and peaked after 350ms. Also, in line with previous experiments, it decreased but remained clearly evident beyond 400ms (see Figure 7b). A clear difference between the amplitudes for related and unrelated prime/target pairs was noted, with more negative waveforms for unprimed than primed faces. Moreover, a stronger familiarity effect was detected over the right hemisphere in the related condition (500-600ms; Figure 7c). These observations were largely supported by statistical analysis.

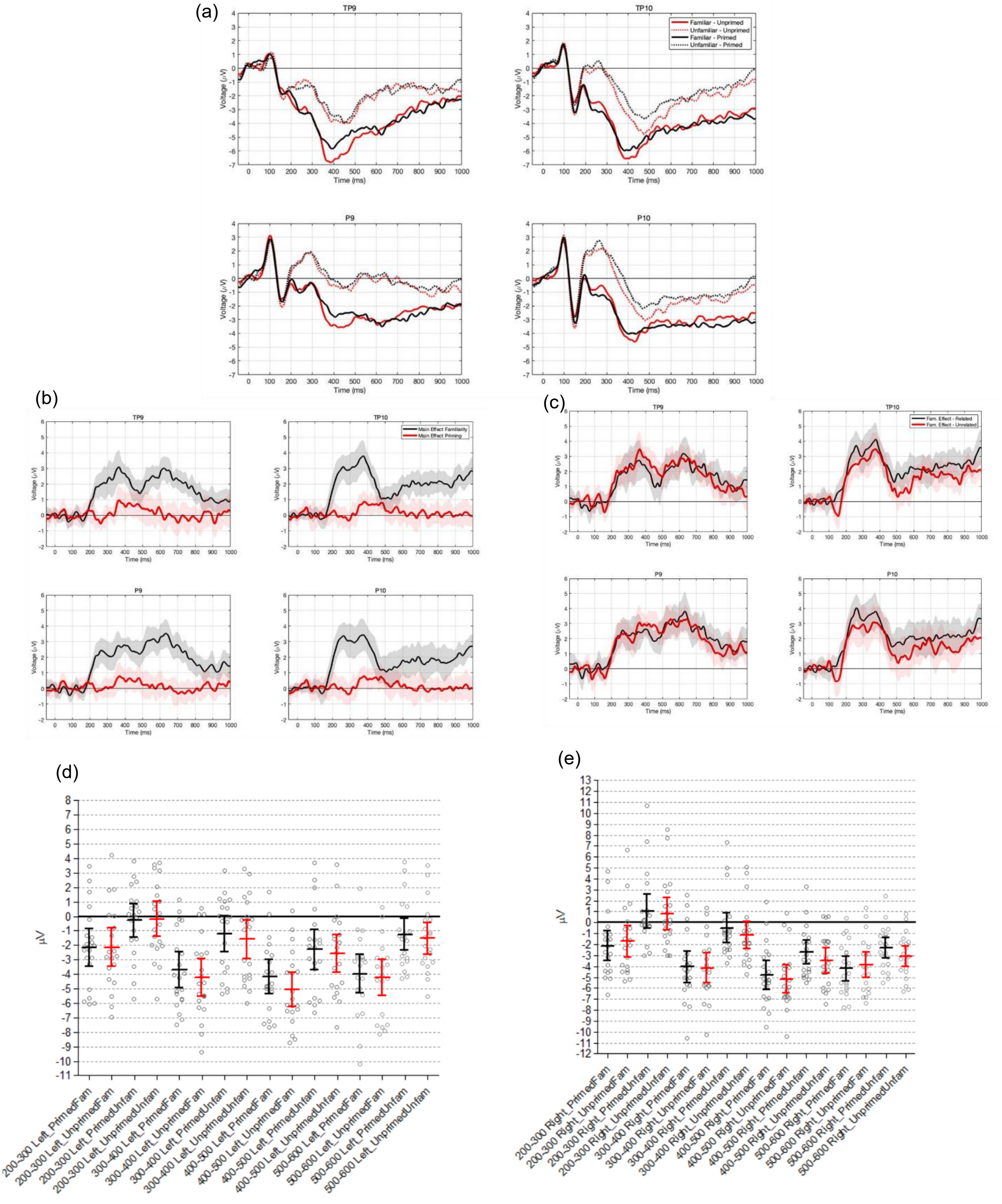

Figure 7. Results for Experiment 2 (Associative Priming). (a) Grand average event-related potentials for related/unrelated familiar and unfamiliar faces at occipito-temporal electrodes over the left and right hemisphere. (b) Mean (+/−95% CI) difference curves for the familiarity effect (unfamiliar – familiar) and priming effect (unrelated – related). (c) Mean (+/- 95% CI) difference curves for the familiarity effect in the related and unrelated conditions separately. (d - e) Mean (+/- 95% CI) and individual responses to each priming and familiarity condition displayed for 100ms time windows from 200-600ms, separately for the left (d) and right (e) hemisphere.

Event-related potentials

200-300:

A repeated-measures ANOVA in the N250 time window (200-300ms) with the factors electrode site (TP, P), hemisphere (right, left), familiarity (familiar, unfamiliar) and priming (primed, unprimed) yielded a significant main effect of site, $F(1, 19) = 18.539$, $p < .001$, $\eta^2_p = .494$, and familiarity, $F(1, 19) = 54.367$, $p < .001$, $\eta^2_p = .741$, with familiar faces eliciting more negative amplitudes than unfamiliar faces, which is in line with the results of Experiment 1.

A significant interaction of hemisphere by familiarity was detected, $F(1, 19) = 16.877$, $p = .001$, $\eta^2_p = .470$. The familiarity effect was significant at left hemisphere electrodes, $F(1, 19) = 36.418$, $p <.001$, $\eta^2_p = .657$ and over the right hemisphere, $F(1, 19) = 9.483$, $p =.006$, $\eta^2_p = .333$, but with a lower effect size. Even though the priming effect was not significant at this time point, $F(1, 19) = .274$, $p = .606$, $\eta^2_p = .014$, a significant interaction of hemisphere by familiarity x priming was detected, $F(1, 19) = 9.291$, $p = .007$, $\eta^2_p = .328$.

The priming effect was then tested separately in both familiarity conditions (familiar and unfamiliar), demonstrating that there was no significant difference between the unprimed and primed faces over the left and right hemisphere in the N250 time window, which is also consistent with the findings of Experiment 1.

300-400:

A corresponding ANOVA in the 300-400ms time window revealed a significant main effect of site, $F(1, 19) = 30.058$, $p < .001$, $\eta^2_p = .613$, and familiarity, $F(1, 19) = 57.454$, $p < .001$, $\eta^2_p = .751$, with consistently more negative-going amplitudes for familiar versus unfamiliar faces.

Similarly, a significant interaction of hemisphere by familiarity was found, $F(1, 19) = 7.233$, $p = .015$, $\eta^2_p = .276$. Moreover, the analysis within this time frame revealed a significant main effect of priming, $F(1, 19) = 5.023$, $p =.037$, $\eta^2_p = .209$, with more negative amplitudes elicited by unprimed than primed prime/target pairs.

The analysis of this time window has also detected a significant interaction of hemisphere by familiarity x priming, $F(1, 19) = 5.474$, $p = .030$, $\eta^2_p = .224$. Consequently, follow-up comparisons (Table 6) revealed a significant effect of priming in conditions where the target faces were familiar, which was clearly limited to the left hemisphere. Conversely, over the right hemisphere, this analysis detected a clear difference between responses to primed and unprimed faces which emerged only when the targets were unfamiliar to the participant.

400-500:

Further analysis detected a significant main effect of site, $F(1, 19) = 19.363$, $p < .001$, $\eta^2_p = .505$, and familiarity, $F(1, 19) = 51.979$, $p < .001$, $\eta^2_p = .732$, with more negative amplitudes for familiar than unfamiliar faces. Moreover, a significant main effect of priming was found, $F(1, 19) = 13.536$, $p = .002$, $\eta^2_p = .416$, with notably more negative amplitudes for unprimed than primed faces and a larger effect size than the priming effect found in the previous time window. As before, a significant interaction of hemisphere by familiarity x priming was revealed, $F(1, 19) = 6.798$, $p = .017$, $\eta^2_p = .264$.

Further comparisons found a significant difference between the primed and unprimed condition over the left hemisphere, limited to familiar faces. At the right hemisphere, a significant difference was found between primed and unprimed unfamiliar face stimuli (see Table 6). This pattern of results is consistent with the findings obtained from the analysis of the 300-400ms time frame.

500-600:

Further analysis in the later SFE time frame (500-600ms) revealed a significant main effect of site, $F(1, 19) = 12.081$, $p = .003$, $\eta^2_p = .389$, and familiarity, $F(1, 19) = 47.075$, $p < .001$, $\eta^2_p = .712$, with more negative amplitudes for familiar relative to unfamiliar faces. A significant interaction of hemisphere by familiarity was detected, $F(1, 19) = 12.886$, $p = .002$, $\eta^2_p = .404$. The familiarity effect was significant over the left hemisphere, $F(1, 19) = 59.646$, $p < .001$, $\eta^2_p = .758$, and over the right hemisphere, $F(1, 19) = 14.719$, $p = .001$, $\eta^2_p = .437$, even though its effect size was lower.

The main effect of priming was no longer significant, $F(1, 19) = 2.628$, $p = .122$, $\eta^2_p = .121$. However, in-line with the analysis of previous time windows, the interaction of hemisphere by familiarity x priming was significant, $F(1, 19) = 5.486$, $p = .030$, $\eta^2_p = .224$.

Follow-up pairwise comparisons revealed the familiarity effect (unfamiliar – familiar) was significantly larger in the primed than in the unprimed condition, but only over the right hemisphere. Moreover, further results indicate that the amplitudes elicited by unfamiliar faces in the unprimed condition were significantly more negative than these elicited by unfamiliar targets in the primed condition. This is consistent with the findings from the previous time windows (300-400ms, 400-500ms).

Table 6.

Paired-samples comparisons of the ERP amplitudes separately over the left and right hemisphere in the N250 and SFE time windows elicited by different priming and familiarity conditions.

	M_{diff} (μV)	95% *CI*	*t*(19)	*p*	d_z	95% *CI*
200-300ms – left hemisphere						
Familiar Target – R vs NR	0.003	-0.314, 0.319	0.020	.985	0.004	-0.434, 0.443
Unfamiliar Target – R vs NR	0.110	-0.485, 0.705	0.387	.703	0.087	-0.354, 0.524
Familiar vs Unfamiliar – R	1.858	1.167, 2.550	5.625	<.001	1.258	0.657, 1.840
Familiar vs Unfamiliar – NR	1.971	1.200, 2.743	5.349	<.001	1.196	0.609, 1.766
Fam. Effect R vs Fam. Effect NR	0.113	-0.505, 0.731	0.383	.706	0.086	-0.355, 0.524
200-300ms – right hemisphere						
Familiar Target – R vs NR	0.398	-0.030, 0.826	1.946	.067	0.435	-0.029, 0.889
Unfamiliar Target – R vs NR	0.197	-0.260, 0.654	0.903	.378	0.202	-0.243, 0.642
Familiar vs Unfamiliar – R	3.133	2.304, 3.962	7.907	<.001	1.768	1.050, 2.469
Familiar vs Unfamiliar – NR	2.538	1.714, 3.361	6.450	<.001	1.442	0.801, 2.065
Fam. Effect R vs Fam. Effect NR	0.595	-0.052, 1.243	1.924	.069	0.430	-0.034, 0.884
300-400ms – left hemisphere						
Familiar Target – R vs NR	0.516	0.010, 1.021	2.135	.046	0.477	0.008, 0.935
Unfamiliar Target – R vs NR	0.372	-0.368, 1.111	1.052	.306	0.235	-0.212, 0.677
Familiar vs Unfamiliar – R	2.517	1.521, 3.513	5.291	<.001	1.183	0.598, 1.750
Familiar vs Unfamiliar – NR	2.661	1.746, 3.577	6.085	<.001	1.361	0.738, 1.965
Fam. Effect R vs Fam. Effect NR	0.144	-0.662, 0.950	0.374	.713	0.084	-0.357, 0.522
300-400ms – right hemisphere						
Familiar Target – R vs NR	0.102	-0.430, 0.635	0.402	.692	0.090	-0.350, 0.528

Unfamiliar Target – R vs NR	0.646	0.129, 1.163	2.613	.017	0.584	0.102, 1.053
Familiar vs Unfamiliar – R	3.560	2.589, 4.531	7.674	<.001	1.716	1.010, 2.403
Familiar vs Unfamiliar – NR	3.017	2.152, 3.882	7.299	<.001	1.632	0.947, 2.299
Fam. Effect R vs Fam. Effect NR	0.543	-0.186, 1.273	1.559	.135	0.349	-0.108, 0.796
400-500ms – left hemisphere						
Familiar Target – R vs NR	0.903	0.314, 1.492	3.209	.005	0.718	0.217, 1.203
Unfamiliar Target – R vs NR	0.265	-0.268, 0.799	1.041	.311	0.233	-0.214, 0.674
Familiar vs Unfamiliar – R	1.872	1.125, 2.619	5.247	<.001	1.173	0.590, 1.738
Familiar vs Unfamiliar – NR	2.510	1.733, 3.286	6.763	<.001	1.512	0.855, 2.151
Fam. Effect R vs Fam. Effect NR	0.637	-0.065, 1.340	1.898	.073	0.424	-0.039, 0.878
400-500ms – right hemisphere						
Familiar Target – R vs NR	0.389	-0.120, 0.898	1.599	.126	0.358	-0.099, 0.806
Unfamiliar Target – R vs NR	0.755	0.199, 1.312	2.843	.010	0.636	0.147, 1.111
Familiar vs Unfamiliar – R	2.071	1.207, 2.936	5.016	<.001	1.122	0.549, 1.676
Familiar vs Unfamiliar – NR	1.705	0.947, 2.463	4.706	<.001	1.052	0.494, 1.594
Fam. Effect R vs Fam. Effect NR	0.366	-0.357, 1.090	1.060	.302	0.237	-0.211, 0.679
500-600ms – left hemisphere						
Familiar Target – R vs NR	0.256	-0.438, 0.949	0.771	.450	0.173	-0.271, 0.612
Unfamiliar Target – R vs NR	0.252	-0.179, 0.683	1.222	.237	0.273	-0.177, 0.716
Familiar vs Unfamiliar – R	2.701	1.774, 3.628	6.099	<.001	1.364	0.740, 1.969
Familiar vs Unfamiliar – NR	2.705	1.887, 3.522	6.924	<.001	1.548	0.883, 2.195
Fam. Effect R vs Fam. Effect NR	0.004	-0.949, 0.957	0.009	.993	0.002	-0.436, 0.440
500-600ms – right hemisphere						
Familiar Target – R vs NR	0.315	-0.249, 0.879	1.169	.257	0.261	-0.188, 0.704
Unfamiliar Target – R vs NR	0.735	0.228, 1.242	3.036	.007	0.679	0.184, 1.160
Familiar vs Unfamiliar – R	1.871	1.135, 2.607	5.318	<.001	1.189	0.603, 1.757

Familiar vs Unfamiliar – NR	0.821	0.006, 1.636	2.108	.049	0.471	0.003, 0.929
Fam. Effect R vs Fam. Effect NR	1.050	0.543, 1.557	4.337	<.001	0.970	0.427, 1.496

4.4. Discussion

The purpose of Experiment 2 was to expand on the findings of Experiment 1 and further investigate the influence of priming on the recognition of personally familiar and unfamiliar *people* from their faces, either preceded by a highly associated name or by an unrelated name. In this way, we expected to manipulate access to domain-general person representations (PINs, Burton et al., 1990) via top-down input from representations storing identity-specific knowledge about familiar individuals, shared by those closely associated with each other (Burton et al., 2011; Schwartz & Yovel, 2019). A key goal of this study was to further look into the potential influence of predicting a response to the target on the ERP amplitudes elicited by either primed or unprimed unfamiliar and familiar faces, which has been initially detected in Experiment 1.

4.4.1 Behavioural Results

Accuracy was close to ceiling level in all priming and familiarity conditions (see Table 5). Nonetheless, priming familiar faces with associatively related names significantly enhanced the speed of RTs to familiarity decisions (familiar/unfamiliar target). Moreover, while the differences were not statistically significant, it seems that priming familiar faces resulted in slightly faster RTs than priming unfamiliar faces, whereas participants were slower to react to familiar rather than unfamiliar faces preceded by an unrelated name (see Table 4). Cumulatively, this likely resulted in the lack of a priming effect for unfamiliar faces.

These results point to a significant influence of top-down processing on the facilitated activity of person representations which resulted in faster recognition, potentially due to the input from identity-specific *person knowledge* (Schweinberger, 1996; Wiese & Schweinberger, 2015; Ramon & Gobbini, 2018). This is because the effect was restricted to familiar conditions, which should be the ones associated with domain-general representations unavailable for unfamiliar people (Burton et al., 1990).

Although this study has not differentiated between categorical or associative relatedness between the pairs of people used as stimuli, it explored the influence of priming on the recognition of naturally variable photographs of people the participants were closely familiar with in real-life (see Wiese, 2011). These behavioural results are still in line with previous research using prime and target stimuli associated on both; co-occurrence and a semantic/categorical relationship (e.g. one's mother and father may co-occur, but also share a strong semantic link; Bruce, 1983; Bruce & Valentine, 1986; Young et al., 1988; Stone, 2008). Close association has been consistently found to prime person recognition, holding an advantage over purely categorical relatedness (e.g. two people who share the same occupation, but do not co-occur; Stone, 2008). Vladeanu et al. (2006) confirmed that gaining knowledge from a pairs' co-occurrence *and* semantics resulted in the strongest within-domain priming effect which has been attributed to top-down activation of related person representations.

However, as mentioned in Chapter 3.4*,* a relatively long SOA has been used in the present methodology (800ms), which is why it is important to consider whether strategic processing could have influenced these results by facilitating the recognition of primed familiar targets (Bruce & Valentine, 1986; Brennen & Bruce, 1991; Wiese, 2011). This seems unlikely, since the prime accurately informed the participants of the upcoming target's familiarity only in 50% of the trials, making this strategy unreliable. There is also no strong evidence for the influence of response priming, where incongruent primes would elicit a significantly slower RT in the familiar and unfamiliar target conditions (Schmidt et al., 2011; Wentura & Rothermund, 2014), which was not the case in the latter. There is still a possibility that the predictive coding has influenced the neural responses to familiar and unfamiliar targets, eliciting P3-like effects that will be analysed in the following section.

4.4.2 ERP Results

In accordance with the initial predictions, Experiment 2 detected a strong N250 familiarity effect which was equally significant for primed and unprimed conditions. Neither associatively related or unrelated prime names had any notable influence on the amplitudes elicited by familiar and unfamiliar faces in the earliest ERP time window (200-300ms) selected for the present analysis, confirming that it reflects a domain-sensitive stage of face processing. As described by previous research, the N250 familiarity effect in the present study was relatively robust and image-independent, since it has been reliably activated by different images depicting a familiar person's face which captured a notable degree of their within-person variability (Jenkins et al., 2011; Burton, 2013; Andrews et al., 2017).

However, in line with Experiment 1, this applied only to the earliest N250 time frame examined, as cross-domain priming significantly influenced the ERP amplitudes elicited by familiar (left hemisphere) and unfamiliar (right hemisphere) faces from 300-400ms. This confirms that primes from a different stimulus modality than the target face can still regulate how it is processed, which indicates that the 300-400ms time window of the N250 (Wiese et al., 2023) may reflect a more domain-general stage of identity processing, related to the integration of information provided by the prime name in relation to the viewed face (Burton et al., 1990; Wiese et al., 2017)

Moreover, the familiarity effect remained significant beyond the N250, as the SFE was detected from 400-600ms. However, the size of the SFE was again smaller compared to prior research, varying between 1 µV and a maximum of 3 µV, instead of the 4 µV commonly observed in other ERP studies (see Figure 7b; Wiese et al., 2019c; Wiese et al., 2022a; Wiese et al., 2022b). Importantly, the SFE was still significantly larger in the primed than in the unprimed condition from 500-600ms over the right hemisphere (Table 6), which is later than a similar observation made in Experiment 1 (300-400ms; Table 3). It can be argued that this delay occurred because associative priming requires the participants to integrate information about two different people, even in *primed familiar* trials, which may be more time-consuming or cognitively demanding than the integration of name and face information associated with the same person during self-priming (Calder & Young; 1996). Therefore, these findings suggest that the SFE may have been modulated by the post-perceptual processes involved in associative priming which likely facilitated top-down access to the domain-general person representations of related individuals who were familiar to the participant (Burton et al., 1990; Schweinberger, 1996; Wiese & Schweinberger, 2011).

A consistent pattern of the associative priming effect was also observed, with more negative amplitudes for unprimed faces compared to primed faces from 300-500ms, partially aligning with the observed SFE. This cannot be identified as the N400 effect, as the direction of this difference is the opposite of what was expected over the occipito-temporal electrodes analysed (Pickering & Schweinberger, 2003). Nonetheless, a significant impact of priming on the amplitudes elicited by familiar faces over the *left* hemisphere was found from around 300-500ms. In turn, an overlapping priming effect for unfamiliar faces was shown over the *right* hemisphere from 300-600ms (see Table 6). The more left-lateralized priming effect for familiar faces implies a significant role of name processing for the subsequent recognition of their association with personally known people (e.g. NRUs; Burton et al., 1990; Gainotti, 2013). Previous associative priming research has also noted the strongest influence of priming when the prime stimuli were presented to the right hemisphere (i.e. in the left visual field; Vladeanu & Bourne, 2009; Gainotti, 2013), partially contradicting with the present results which detected such a right-lateralized effect of priming only for unfamiliar faces.

Consequently, these findings suggest a prominent role of predictive coding in eliciting this effect, likely resulting from response priming of a specific familiarity response with either congruent or incongruent name primes (Schmidt et al., 2011). In line with Experiment 1, the significant influence of priming could be associated with the P3b-like effect sensitive to stimuli which unexpectedly deviate from the existing context, which has likely been established based on the top-down input from the associated prime (e.g. seeing a family member's name leading to the prediction of a familiar target; Polich, 2007; Amado et al., 2018; Reichardt et al., 2020). In addition, a response-related P3 effect was previously argued to contaminate an expected N400 during semantic priming of a speeded lexical decision task (see 3.4.2.; van Vliet et al., 2014). This process is likely post-perceptual in nature, however, it cannot be confidently associated only with the facilitated access to person-related knowledge (Wiese et al., 2017; Wiese et al., 2022b), since it was also found for unfamiliar faces. As such, it may be argued that the prediction of a categorical response to the target (familiar/unfamiliar) has been reflected by the priming effect measured in Experiment 1 and 2 (Schmidt et al., 2011; Amado et al., 2018). Related processes may interfere with the SFE when compared to the familiarity effect elicited in tasks without additional cognitive demands (Wiese et al., 2022b), while still enhancing it in conditions when the predicted and the actual target category match at later ERP time frames (500-600ms).

Therefore, the present findings demonstrate primes associated with a target likely provide context which may be needed for an upcoming interaction with a specific person, while unrelated primes do not. Any post-perceptual assessment and updating of a given context to integrate it with the incoming stimuli can be considered essential to prepare for a potential interaction with the environment (e.g. a personally familiar person; Wiese et al., 2023).

Chapter 5

Neural Underpinnings of Familiar Person Recognition:

Evidence from the Influence of Repetition Priming on the N250 and the Sustained Familiarity Effect

5.1. Introduction

Experiment 3 examined whether the neural correlates of face recognition, the N250 and the SFE, are significantly influenced by immediate within-domain repetition priming. The two prior experiments have investigated the neural underpinnings of person recognition, subsequent to the perceptual processing stages needed to distinguish between known and previously unseen faces (Burton et al., 1990). However, this investigation cannot be complete without a consideration of whether the ERP familiarity effects (the N250 and the SFE) may be influenced by domain-specific input, facilitating access to the robust and image-invariant representations of known faces (Bruce & Young, 1986; Schweinberger et al., 1995). The N250 differentiates between familiar vs unfamiliar faces. It is sensitive to face stimuli and occurs relatively automatically, which is why it has been associated with long-term perceptual representations of faces (Gosling & Eimer, 2011; Wiese et al., 2022b).

Earlier electrophysiological research has consistently found that significantly more negative amplitudes are elicited at approximately 250ms by repeated rather than non-repeated familiar faces (the N250r; Schweinberger et al., 1995; Neumann et al., 2011; Chapter 1.5.2). The immediate and within-domain repetition priming effect is generally much stronger than the previously examined self-priming effect (Calder et al., 1996; Calder & Young, 1996). According to the IAC model, this is because any photograph of a known face should facilitate recognition by pre-activating the domain-specific FRU and, subsequently, access to the related PIN. In turn, self-priming only enhances the activity of an associated PIN, as the target is from a different stimulus domain than the prime (Burton et al., 1990; Calder & Young, 1996; Zimmerman & Eimer, 2013).

Experiment 1 and 2 did not find a significant impact of introducing a cross-domain prime related to the familiar target on the magnitude of the N250 from 200-300ms. However, some influence of priming on the waveforms elicited by familiar and unfamiliar targets from 300-400ms have been detected in Experiment 1 and 2, which should be investigated further by examining whether this effect is also found when within-domain repetition priming is used.

These questions will be addressed with the repetition priming design, investigating the extent to which the N250 and the SFE are influenced by the facilitated access to long-term visual representations of a face. Specifically, we will consider whether the pre-activation of face representations or the expectation of an upcoming familiar or an unfamiliar target will modulate the corresponding ERP waveforms at the domain-specific level.

5.2 Methodology

5.2.1 Participants

We tested 20 Durham University undergraduate and postgraduate students (16 female, mean age = 20.6, *SD* = 2.11). A modified Edinburgh Handedness Inventory (Oldfield, 1971) found that 18 participants reported dominant right-handedness and two participants were left-handed (mean laterality quotient = 69.65, *SD* = 46.36; see Appendix E). Compensation, exclusion and inclusion criteria, ethical considerations and obtaining participant consent was consistent with Experiment 1 and 2. This experiment was also approved by the ethics committee of the Durham University Psychology department.

5.2.2 Stimuli

Collection and preparation of stimuli used during the Repetition Priming study has been discussed in section 2.1 of the General Methods.

5.2.3 Procedure

The procedure of the Repetition Priming experiment has been described in section 2.2 of the General Methods. The prime stimulus in this paradigm was always a face image which could be followed by the target depicting either the same or a different identity (see Figure 4c). Therefore, the four experimental conditions in the Repetition Priming design were Primed Familiar, Unprimed Familiar, Primed Unfamiliar and Unprimed Unfamiliar. Each of the 24 familiar and 24 unfamiliar images provided by a participant pair was used once as a prime and once as a target in both experimental blocks. The prime and target were never the same image to avoid any effects related to picture rather than identity repetition.

5.2.4 EEG recording and data analysis

A detailed description of the EEG recording, and the data analysis parameters utilised were provided in section 2.3. After the EEG artifact rejection, the average number of trials accepted for further analysis was 46.85 (SD = 1.28, min = 43) for the Primed Familiar condition, 46.5 (SD = 1.47, min = 43) for Unprimed Familiar condition, 46.9 (SD = 1.3, min = 44) for Primed Unfamiliar and 46.5 (SD = 1.6, min = 41) for the Unprimed Unfamiliar condition. The resulting waveforms underwent the statistical analysis steps disclosed in the General Methods section.

5.3 Results

5.3.1 Performance

The reaction time (RT) and accuracy of participants (n = 18) when making familiarity judgements of the target face were measured for each experimental condition (Table 7 and 8). Two participants were excluded from this behavioural results analysis as they repeatedly failed to indicate the familiarity of a target face in the time window of 1000ms during which the target was visible on the screen.

Reaction Times

Table 7.

The average reaction times (mean and standard deviation) for making an accurate familiarity decision for familiar and unfamiliar targets across conditions.

	Familiar Faces			Unfamiliar Faces		
	Primed	Unprimed	Priming Effect	Primed	Unprimed	Priming Effect
M (ms)	514.39	489.18	-25.21	508.43	524.16	15.73
SD	74.20	67.71	29.75	70.71	66.69	24.75

A repeated-measures ANOVA with factors target familiarity (familiar, unfamiliar) and priming (primed, unprimed) was conducted to determine whether the RTs significantly differed between experimental conditions. A significant main effect of familiarity was detected, $F(1, 17) = 5.20$, $p = .036$, $\eta^2_p = .234$, with unfamiliar targets eliciting on average longer RTs than familiar targets across all conditions. There was no significant effect of priming, $F(1, 17) = 0.79$, $p = .385$, $\eta^2_p = .045$. Additionally, a significant interaction of familiarity by priming was found, $F(1, 17) = 31.50$, $p < .001$, $\eta^2_p = .649$. This interaction was followed-up using paired-samples t-tests.

First, it is essential to note that the priming effect (unprimed – primed targets) significantly differed between unfamiliar and familiar conditions, $\mathrm{M}_{\mathrm{diff}} = -40.94$, 95% CI [-56.331, -25.551], $t(17) = -5.613$, $p < .001$, $d_z = -1.323$, 95% CI [-1.951, -.674]. This was investigated further by comparing the influence of identity repetition on the RTs for rating the familiarity of familiar and unfamiliar faces.

Contrary to the initial hypothesis, participants took longer to determine the familiarity of a target when the same familiar face was repeated (primed familiar), compared to trials with a prime different from the familiar target (unprimed familiar), $\mathrm{M}_{\mathrm{diff}} = -25.21$, 95% [-40.01, -10.41], $t(17) = -3.60$, $p = .002$, $d_z = -.847$, 95% CI [-1.380, -.297]. Conversely, participants were significantly faster to respond when presented with primed rather than unprimed unfamiliar faces, $\mathrm{M}_{\mathrm{diff}} = 15.73$, 95% CI [3.422, 28.041], $t(17) = 2.70$, $p = .015$, $d_z = .636$, 95% CI [.120, 1.136].

In addition, differences in RTs between familiar and unfamiliar conditions were examined separately for each priming condition. There was no significant difference between RTs to familiar versus unfamiliar faces in the primed condition, $\mathrm{M}_{\mathrm{diff}} = 5.97$, 95% CI [-9.778, 21.710], $t(17) = 0.80$, $p = .435$. Still, there was a significant difference between RTs to familiar versus unfamiliar faces in the unprimed condition, $\mathrm{M}_{\mathrm{diff}} = 34.98$, 95% CI [19.781, 50.169], $t(17) = 4.86$, $p < .001$, $d_z = 1.145$, 95% CI [.535, 1.734]. Participants were faster when responding to unprimed familiar faces.

Accuracy

Table 8.

The average accuracy (mean and standard deviation) for making a familiarity decision for familiar and unfamiliar targets across conditions.

	Familiar Faces	Unfamiliar Faces

	Primed	Unprimed	Priming Effect	Primed	Unprimed	Priming Effect
M	0.91	0.92	0.02	0.93	0.91	-0.02
SD	0.20	0.20	0.04	0.20	0.20	0.05

An ANOVA with the same factors as for the RT analysis was conducted to investigate any differences in the accuracy of familiarity judgements across familiarity and priming conditions. No main effect of familiarity, $F(1, 17) = .558, p = .465, \eta^2_p = .032$, or priming, $F(1, 17) = .215, p = .649, \eta^2_p = .012$ was observed. However, a significant interaction of familiarity by priming was found, $F(1, 17) = 5.88, p = .027, \eta^2_p = .257$.

A follow-up paired samples t-test found that participants were not significantly different when judging the familiarity of known targets, with no impact of priming, $M_{diff}= 0.01$, 95% CI [-.006, .035], $t(17) = 1.493, p = .154$. Similarly, there was no significant difference in accuracy between priming conditions when determining whether an unknown face is familiar, $M_{diff}= -0.02$, 95% CI [-.047, .003], $t(17) = -1.840, p = .083$. Still, the priming effect for accuracy significantly differed between the familiar and unfamiliar conditions, $M_{diff}= 0.04$, 95% CI [.005, .069], $t(17) = 2.424, p = .027, d_z = 0.571$, 95% CI [.065, 1.064].

5.3.2 Event-related potentials

The ERP results obtained from the Repetition Priming study are depicted in Figure 8 a-d and Figure 9. A visual inspection of Figure 8a revealed clear familiarity effects over the occipito-temporal electrodes, with familiar faces eliciting more negative waveforms than unfamiliar faces from approximately 200ms. This is also evident when investigating the difference waves on Figure 8b, where the main effect of familiarity peaks at around 350ms after stimulus onset. This difference appears still clear but notably reduced in the SFE time window (400-600ms).

In direct opposition to prior research and the present hypotheses, Experiment 3 did not find the expected N250r effect. We observed a repetition priming effect for unfamiliar but not familiar targets in the N250r time window (see Figure 8a). Moreover, there was a clear difference between priming conditions at a later time point (400-600ms), with more negative amplitudes elicited by non-repeated than repeated familiar targets. Conversely, more negative amplitudes were detected for primed than unprimed unfamiliar targets (Figure 8d). Additionally, a stronger familiarity effect was consistently detected for unprimed faces (Figure 8c, Figure 9). These observations were supported by statistical data analysis.

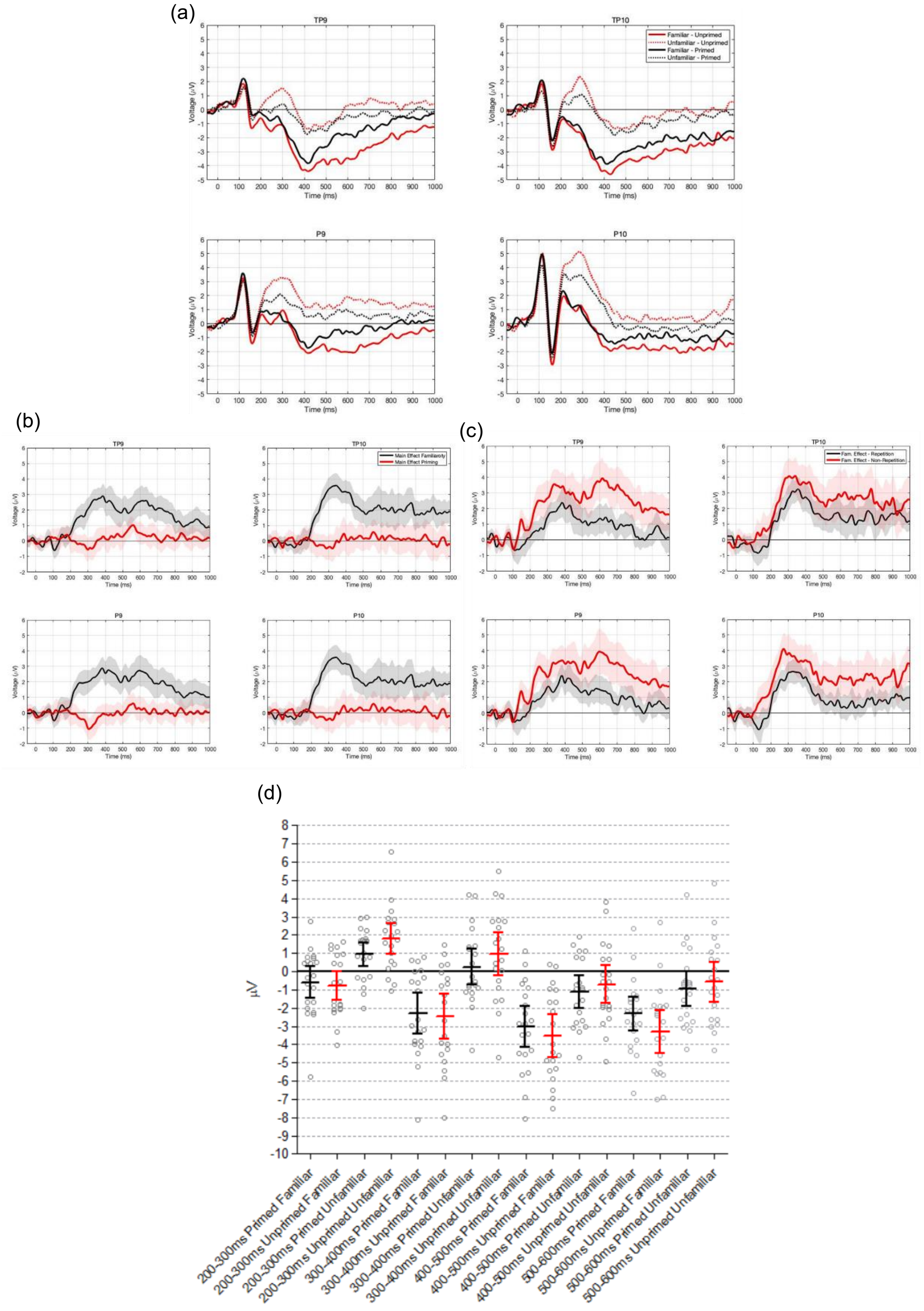

Figure 8. Results for Experiment 3 (Repetition Priming). (a) Grand average event-related potentials for primed/unprimed familiar and unfamiliar faces at occipito-temporal electrodes over the left and right hemisphere. (b) Mean (+/−95% CI) difference curves for the familiarity effect (unfamiliar – familiar) and priming effect (unprimed – primed). (c) Mean (+/- 95% CI) difference curves for the familiarity effect in the primed and unprimed conditions separately. (d) Mean (+/- 95% CI) and individual responses to each priming and familiarity condition displayed for 100ms time windows from 200-600ms.

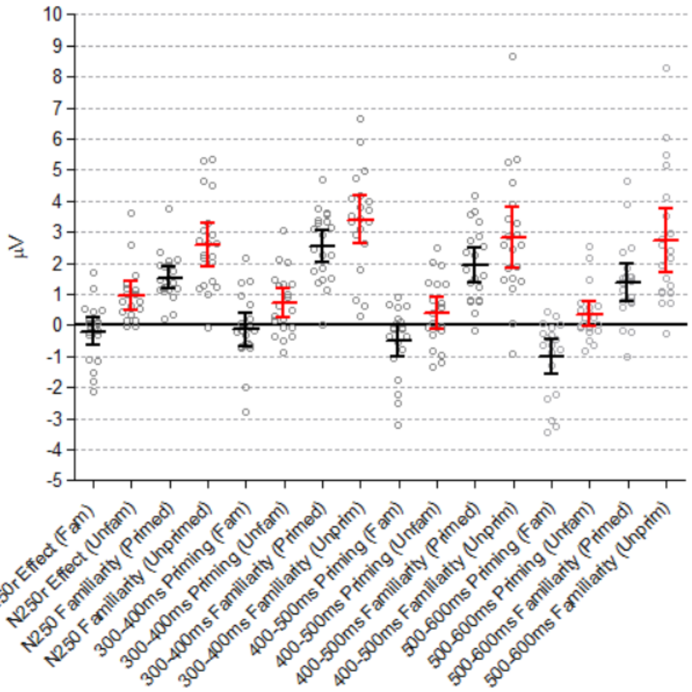

Figure 9. Results for Experiment 3 (Repetition Priming). Mean (+/- 95% CI) and individual responses for the main effects of **priming** and **familiarity** in each of the primed, unprimed, familiar and unfamiliar conditions displayed for 100ms time windows from 200 to 600ms.

200-300 ms:

A repeated-measures ANOVA in the N250r time window (200-300ms) with the factors electrode site (TP, P), hemisphere (right, left), familiarity (familiar, unfamiliar) and priming (primed, unprimed) revealed a significant main effect of site, $F(1, 19) = 33.136$, $p < .001$, $\eta^2_p = .636$, and familiarity, $F(1, 19) = 98.101$, $p < .001$, $\eta^2_p = .838$, with familiar faces eliciting notably more negative amplitudes than unfamiliar faces.

Significant interactions of site by familiarity, $F(1, 19) = 4.410$, $p = .049$, $\eta^2_p = .188$ and hemisphere by familiarity, $F(1, 19) = 18.634$, $p < .001$, $\eta^2_p = .495$ were detected as well. This indicates there was a larger familiarity effect found at the more anterior electrodes (i.e. TP10) over the right hemisphere. Moreover, this analysis yielded a significant main effect of priming, $F(1, 19) = 5.784$, $p = .027$, $\eta^2_p = .233$. Interestingly, it found a significant interaction of familiarity by priming, $F(1, 19) = 11.382$, $p = .003$, $\eta^2_p = .375$. Subsequent comparisons with paired-samples t-tests (see Table 9) revealed there was no significant difference between the amplitudes elicited by repeated and non-repeated familiar identities. As such, the expected N250r effect was not detected in the present work.

Nonetheless, an unexpected influence of priming was found to be significant when participants were shown unfamiliar faces as targets, with repeated unfamiliar faces eliciting more negative amplitudes (Figure 8d). Furthermore, there was a significant difference between the magnitude of the familiarity effect in the primed and unprimed conditions. The difference between waveforms responding to unfamiliar vs familiar faces was lower for repeated than for non-repeated faces.

300-400:

A further ANOVA in the late N250 (300-400ms) time window revealed a significant main effect of site, $F(1, 19) = 28.254$, $p < .001$, $\eta^2_p = .598$, and familiarity, $F(1, 19) = 126.306$, $p < .001$, $\eta^2_p = .869$, with more negative-going amplitudes for familiar versus unfamiliar faces. Significant interactions were detected for site by familiarity, $F(1, 19) = 4.948$, $p = .038$, $\eta^2_p = .207$, and hemisphere by familiarity, $F(1, 19) = 8.365$, $p = .009$, $\eta^2_p = .306$.

Although the priming main effect was no longer significant in this time window, $F(1, 19) = 2.762$, $p = .113$, $\eta^2_p = .127$, the analysis yielded a significant interaction of site by priming, $F(1, 19) = 10.944$, $p = .004$, $\eta^2_p = .365$, and of familiarity by priming, $F(1, 19) = 6.387$, $p = .021$, $\eta^2_p = .252$.

Further comparisons included in Table 9 revealed that the amplitudes elicited by primed unfamiliar faces were significantly more negative than in the unprimed unfamiliar condition, which was consistent with the results obtained via the analysis of the 200-300ms time window. There was no influence of priming on the amplitudes elicited by familiar faces. Moreover, the familiarity effect remained significantly lower in the identity repetition than in the non-repetition condition (Table 9 and Figure 8c, 9).

400-500ms:

Subsequently, the ANOVA in the SFE time window (400-500ms) yielded a significant main effect of site, $F(1, 19) = 17.016$, $p = .001$, $\eta^2_p = .472$, and familiarity, $F(1, 19) = 51.909$, $p < .001$, $\eta^2_p = .732$, where familiar faces elicited more negative amplitudes than unfamiliar faces. Moreover, the main effect of priming was not significant, $F(1, 19) = .071$, $p = .793$, $\eta^2_p = .004$. Still, there was a significant interaction of site by priming, $F(1, 19) = 9.849$, $p = .005$, $\eta^2_p = .341$, and of familiarity by priming, $F(1, 19) = 5.399$, $p = .031$, $\eta^2_p = .221$. However, further comparisons did not detect significant differences between the amplitudes elicited by primed and unprimed faces in either familiarity conditions.

In line with the findings from the analysis of previous time windows, subsequent comparisons revealed the familiarity effect was still present in both priming conditions and significantly larger for non-repeated than repeated target stimuli (Table 9).

500-600ms:

Further ANOVA analysis in the later SFE time frame (500-600ms) revealed a significant main effect of site, $F(1, 19) = 9.819$, $p = .005$, $\eta^2_p = .341$, and familiarity, $F(1, 19) = 35.967$, $p < .001$, $\eta^2_p = .654$, with familiar faces eliciting more negative amplitudes than unfamiliar faces. Importantly, a significant main effect of priming was also found, $F(1, 19) = 7.263$, $p = .014$, $\eta^2_p = .277$.

Moreover, this investigation yielded a significant interaction of site by priming, $F(1, 19) = 4.637$, $p = .044$, $\eta^2_p = .196$, and of familiarity by priming, $F(1, 19) = 11.072$, $p = .004$, $\eta^2_p = .368$. Follow-up comparisons revealed that the difference between unprimed and primed conditions was statistically significant only for the waveforms responding to familiar targets. Unprimed familiar faces elicited significantly more negative amplitudes than primed familiar targets (Table 9). Still, it is important to note that a visual examination of grand-average ERPs in Figure 8 noted that amplitudes in the primed unfamiliar condition were visibly more negative than ones in the unprimed unfamiliar condition, even though a statistically significant difference was not detected between the two (Table 9).

As at previous time windows, further comparisons found the familiarity effect remained significant in both priming conditions but was clearly larger in the non-repeated identity condition (Table 9).

Table 9. Paired-samples comparisons of the ERP amplitudes in the N250r and SFE time windows elicited by different priming and familiarity conditions.

	M_{diff} (μV)	95% *CI*	*t*(19)	*p*	d_z	95% *CI*
200-300ms						
Familiar Target - R vs NR	0.197	0.248, 0.642,	0.926	.366	0.207	0.239, 0.647
Unfamiliar Target - R vs NR	0.864	0.432, 1.230	4.182	.001	0.935	0.398, 1.455
Familiar vs Unfamiliar - R	1.528	1.172, 1.885	8.972	<.001	2.006	1.228, 2.767
Familiar vs Unfamiliar - NR	2.590	1.905, 3.274	7.921	<.001	1.771	1.052, 2.472

Fam. Effect R vs Fam. Effect NR	1.061	0.403, 1.720	3.374	.003	0.754	0.248, 1.246
300-400ms						
Familiar Target - R vs NR	0.140	-0.388, 0.669	0.555	.585	0.124	-0.317, 0.563
Unfamiliar Target - R vs NR	0.708	0.235, 1.181	3.135	.005	0.701	0.203, 1.185
Familiar vs Unfamiliar - R	2.544	2.017, 3.072	10.100	<.001	2.258	1.414, 3.086
Familiar vs Unfamiliar - NR	3.393	2.631, 4.155	9.322	<.001	2.084	1.286, 2.866
Fam. Effect R vs Fam. Effect NR	0.849	0.146, 1.552	2.527	.021	0.565	0.086, 1.032
400-500ms						
Familiar Target - R vs NR	0.491	-0.032, 1.014	1.963	.064	0.439	-0.026, 0.893
Unfamiliar Target - R vs NR	0.409	-0.104, 0.922	1.668	.112	0.373	-0.085, 0.822
Familiar vs Unfamiliar - R	1.918	1.352, 2.484	7.095	<.001	1.586	0.912, 2.243
Familiar vs Unfamiliar - NR	2.818	1.841, 3.795	6.036	<.001	1.350	0.729, 1.952
Fam. Effect R vs Fam. Effect NR	0.900	0.089, 1.710	2.324	.031	0.520	0.046, 0.982
500-600ms						
Familiar Target - R vs NR	0.989	0.425, 1.553	3.669	.002	0.820	0.303, 1.321
Unfamiliar Target - R vs NR	0.354	-0.046, 0.754	1.854	.079	0.415	-0.048, 0.867
Familiar vs Unfamiliar - R	1.388	0.779, 1.997	4.768	<.001	1.066	0.505, 1.610
Familiar vs Unfamiliar - NR	2.731	1.722, 3.740	5.663	<.001	1.266	0.664, 1.850
Fam. Effect R vs Fam. Effect NR	1.343	0.498, 2.188	3.328	.004	0.744	0.239, 1.234

5.4. Discussion

Experiment 3 aimed to contribute to the findings of the previous experiments on self- and associative priming, by investigating the influence of immediate within-domain repetition priming on the recognition of personally familiar and unfamiliar faces, either preceded by the same or by a different face. This was done to facilitate the access to long-term representations of familiar people via the domain-specific input from their faces (Bruce & Young, 1986; Burton et al., 1990) and test whether it will influence the N250 or the subsequent SFE. Another key purpose of the study was to examine whether the prediction of a familiar/unfamiliar response to the target had a significant influence on the ERP amplitudes elicited by repetition priming during face recognition.

5.4.1 Behavioural findings

The accuracy of the participants' responses to target stimuli did not significantly differ between the experimental conditions. Most notably, the results of the present experiment did not align with the pre-established predictions based on research examined in the Introduction. Even though most researchers find that immediate repetition priming elicits faster RTs when the same person's face is presented twice, the opposite was the case in this study (Bruce & Valentine, 1985; Schweinberger et al., 1995; Ellis et al., 1997). These findings additionally contradict the behavioural results of Experiment 1, which found that immediate cross-domain priming does facilitate faster face recognition. In turn, the participants of Experiment 3 responded faster to primed than unprimed *unfamiliar* faces. It is therefore possible that the former effect was a case of response priming, where the prime (i.e. an unfamiliar name) was congruent with the response mapped to the target (i.e. an "unfamiliar" button press), resulting in faster RTs in comparison to the incongruent (unprimed) trials (Schmidt et al., 2011).

However, the unexpected negative influence of priming on the recognition of immediately repeated familiar faces had, to our knowledge, not been previously found in face recognition research. Past research did observe that the repetition effect significantly reduces when increasingly different images of the same person are being used (Ellis et al., 1987), suggesting that the RTs to primed familiar faces could have been suppressed by the image-invariant nature of the stimuli used. Nonetheless, in that case, a reduced but still significant effect of priming or at least a trend in the predicted direction, should have been detected in this study (Ellis et al., 1987).

Alternatively, a post hoc explanation of this unexpected finding is that the participants could have also habituated to the familiar identities (Lewis & Ellis, 2000; Rieth & Huber, 2010). Rieth & Huber (2010) emphasised the importance of a "discounting mechanism", where the perceptual response to a repeatedly presented face would be reduced to avoid source confusion while being presented amongst other faces (Huber, 2014). They found seeing the prime for an increasing amount of time led to habituation and negative priming (i.e. longer

RTs to primed faces). Lewis & Ellis (2000) tested the influence of a large number of familiar identity repetitions (e.g. 80 different images depicting the same face) on recognition. These could have been intermixed with other famous or unfamiliar faces. They observed that repeatedly recognizing the same person initially sped up recognition, however, the RTs started to increase after multiple trials (~20). This effect was reduced, but still detected when distractor faces were presented in between these repetitions; this was most prominent for other familiar identities rather than unfamiliar faces (Lewis & Ellis, 2000). The present results could have also reflected such adaptation to the repeated faces, especially because only two familiar identities were shown repeatedly throughout the experimental blocks as *both* primes and targets, which contrasted with Experiment 1 and 2 (see 2.1. and 2.2.). In the previous experiments, the presentation of name primes could have interfered with the ongoing habituation to faces, which was not the case in this study. Therefore, the participants' RTs likely adapted to the familiar faces throughout the experiment (Rieth & Huber, 2010).

Finally, it is possible that the participants engaged in expectancy-based strategic processing due to the relatively long SOA (800ms) used (Neely, 1977; Becker, 1980; Wiese, 2011). The participants always had a 50% chance that the target following the prime stimulus will be familiar, however, it is possible that actively attempting to predict the outcome after seeing a prime face (either a personally familiar or an unfamiliar person) could have resulted in longer RTs to trials where a target did not coincide with the participants' prior expectations (Posner & Snyder, 1975). It seems unlikely that the participants regularly attempted to predict that an a familiar prime will be followed by an unfamiliar target, although this is implied by the significantly reduced RTs to repeated familiar faces. Given the high variability of unfamiliar stimuli, it may have even been difficult to realise that the same unknown identities are repeated. Still, this possibility should be considered, as the long SOA directly suggests that strategic processes have contributed to these results.

5.4.2 ERP findings

As predicted, the N250 familiarity effect was significant, with more negative-going amplitudes to familiar than unfamiliar faces over the occipito-temporal electrodes. Nonetheless, an unexpected result emerged from the analysis of the repetition priming study, as no evidence of the N250r effect for familiar faces was observed. Meanwhile, a clear and bilateral repetition effect was detected for unfamiliar faces in the same time window and extended to later time frames (~200-400ms).

This is surprising, since any N250r previously elicited by unfamiliar faces has been hypothesized to reflect memory for repeated face images; priming the activation of pictorial representations present for familiar *and* unfamiliar faces (Schweinberger et al., 1995; Schweinberger et al., 2002b; Zimmerman & Eimer, 2013; Schweinberger & Neumann, 2016). Nonetheless, this study found no *picture-specific* repetition effect, as all trials used a different photograph as a prime and a target, while each image was repeated only twice per block. It is therefore possible that this effect may have been elicited by learning from a variety of ambient photographs depicting only two pre-experimentally unfamiliar identities (Kaufmann et al., 2009; Jenkins et al., 2011; Burton et al., 2016; Koca & Oriet, 2023). As outlined in the Introduction, Zimmerman & Eimer (2013) used the occipito-temporal N250r as an index of familiarity with newly learned faces which participants familiarized with in an identity-matching task, where they had to decide whether a pair of images showed the same or different people. Although the photographs used in the present study likely better captured the natural variability of faces, the ones used by Zimmerman & Eimer (2013) still provided participants with depictions of individual faces from different viewpoints. Researchers found a relatively view-independent N250r for repeated images of previously unfamiliar identities, suggesting that this effect may emerge after experimentally gaining familiarity with new faces. Therefore, according to this post hoc explanation, the frequent repetition of two previously unknown faces in this experiment could have resulted in the N250r-like effect observed only for unfamiliar faces.

In addition, the unexpected lack of an N250r for familiar faces also does not align with pre-existing research. It is unlikely that any image-independent repetition effect could have gone undetected by statistical analysis. Although it has previously been found much smaller than the effect elicited by the repetition of the same image (i.e. picture priming), there should still be visible a trend in the expected direction (Schweinberger et al., 2002a; Schweinberger et al., 2002b; Bindemann et al., 2008). Schweinberger et al. (2002a) also did not find the N250r, however, this has been explained with a long SOA (~30 minutes) and many distractor items (~340 other stimuli) intervening with the immediate effect of repetition priming on the expected ERP effects. Conversely, the present study used immediate prime-target repetitions, featuring 24 different images each of two individuals who were familiar to the participants. It is therefore possible that the N250r effect was attenuated due to the frequent repetition of the familiar identities within each block. Repeatedly activating the same face representations (e.g. FRUs; Bruce & Young, 1986) could have resulted in adaptation to the viewed stimuli, potentially related to neural fatigue (i.e. declined firing rates of neurons which initially responded to the repeated stimulus; Grill-Spector et al., 2006). Fatigue-induced changes in how stimuli are processed could additionally explain the reduced performance (longer RTs) when responding to the repeated vs non-repeated faces in this study (Grill-Spector et al., 2006; Ioannucci et al., 2023). Overall, such frequent repetition of two faces could have resulted in a heightened activation of their representations, which together with the strengthened FRU-PIN connections may have not sufficiently deteriorated between trials to elicit a significant difference between the ERPs to repeated and non-repeated *familiar* faces (Burton et al., 1990).

Importantly, this study also found that the familiarity effect was reduced in the identity repetition, compared to the non-repetition trials in the N250 and the SFE time windows. This suggests that repetition priming has modulated the difference between the neural responses to familiar and unfamiliar faces. Although the direction of this effect was unexpected, this demonstrates that domain-specific priming of target faces with face stimuli influences the familiarity response in the 200-300ms time window, previously found unaffected by the presentation of name primes in Experiment 1 and 2 (see 3.4.2 and 4.4.2). This confirms our earlier assumptions that while the 200-300ms time window reflects a domain-sensitive stage of face processing, the 300-400ms time window seems to be associated with domain-general processing of identity (Bruce & Young, 1986; Burton et al., 1990).

In addition, the familiarity effect was reduced in the *primed* conditions, in contrast to the findings of Experiment 1 and 2. This indicates that in trials where domain-specific priming was used, the difference between the neural responses to familiar and unfamiliar faces was attenuated, which was likely due to the methodological factors specific to this experiment. Expanding on the post hoc explanations above, the combined effects of learning repeated unfamiliar faces eliciting an N250r-like modulation (Zimmerman & Eimer, 2013), and the adaptation to the repeated familiar faces (Grill-Spector et al., 2006) reducing the corresponding neural responses, likely contributed to the diminished familiarity effects.

It is also important to note that a priming effect was detected for familiar faces in the final time window analysed (500-600ms). Significantly more negative ERP amplitudes to unprimed than primed targets were observed over the occipito-temporal channels analysed (Figure 8), which could reflect a late P3b-like effect (Polich, 2007). This subsequent influence of priming suggests that participants still likely engaged in the processing of context provided by the viewed faces necessary for an accurate familiarity response to the target (Polich, 2007; Amado et al., 2018; Reed et al., 2022). Nonetheless, this effect was undetected for *unfamiliar* faces, in contrast to Experiment 1 and 2. This explanation also does not align with the behavioural results. Faster, rather than slower RTs would have been expected to congruent prime-target pairs in trials where context-updating would be unnecessary (Kiesel et al., 2008; Schmidt et al., 2011). While repetition priming influences how familiar faces are processed during the later ERP time windows, the properties of this effect remain unclear because of these inconsistencies in our results.

Finally, the SFE has also been significantly diminished in relation to prior research (Wiese et al., 2019c; Wiese et al., 2022b), just as in Experiment 1 and 2. It is unlikely that this difference between the neural responses to familiar and unfamiliar faces was reduced with learning of the previously unknown faces, as Popova & Wiese (2023) noted that only the N250 familiarity effect is significantly modulated by relatively freshly acquired familiarity with a face (5-30 minutes of learning), with no clear changes in the subsequent SFE. Therefore, this points at the more attention-dependent nature of the effect (Wiese et al., 2019b), where the processing of another stimulus (i.e. the prime face) and its familiarity preceding a response to the target could have interfered with the processes reflected in the SFE.

Chapter 6

General Discussion

The present series of three experiments examined whether the N250 familiarity effect and the subsequent SFE would be modulated either by the pre-activation of identity-specific visual and post-perceptual information, or by the prediction of an upcoming familiar or unfamiliar target. Self- (Experiment 1), associative (Experiment 2) and repetition (Experiment 3) priming consistently distinguished between a domain-specific and a domain-general stage of face processing, with the former reflected in the 200-300ms (early N250) time window, and the latter in the subsequent 300-400ms (late N250) time window (Wiese et al., 2019c). Self- and associative priming facilitated access to domain-general person representations via different routes (domain-specific/NRUs and domain-general/SIUs; Burton et al., 1990), which enhanced the coinciding difference between the ERP responses to familiar and unfamiliar faces in restricted time windows (300-400ms in Experiment 1 and 500-600ms in Experiment 2).

While these findings are suggestive of a significant role facilitated post-perceptual processing of person-related knowledge has in regulating the SFE, it was also found related to the cognitive processes engaged in predictive coding. This was concluded based on the significant influence response priming had on the ERP amplitudes elicited by both *familiar* and *unfamiliar* faces (see Figure 6-7), where the prime of each *unprimed* condition informed the participants' predictions with cues contradicting the actual target familiarity. This manipulation produced a P3-like effect, reflecting context-updating necessary for a correct familiarity response to the target. Such post-perceptual processing of a given context to integrate it with the incoming stimuli can be considered essential to prepare for a potential interaction with the environment (Wiese et al., 2023). Since the SFE was consistently reduced in relation to prior research, it can be argued it uses overlapping resources as the integration of contextual information during person recognition. Together, these results suggest that the SFE is a post-perceptual effect which is not automatic and can be influenced by the attentional load allocated to the processing of familiarity information provided by the task-relevant prime stimuli.

The thesis has extended on research still investigating the SFE and actively attempting to localize its functional underpinnings (Wiese et al., 2019b; Wiese et al., 2019c; Wiese et al., 2022a; Wiese et al., 2023). Additionally, it provides an additional lens through which priming effects can be analysed in studies on face recognition (Schweinberger et al., 1995; Calder & Young, 1996; Ellis et al., 1996; Schweinberger & Neumann, 2016; Amado et al., 2018), which will be broken-down in more detail throughout the following paragraphs.

6.1 Evidence of the Priming Effect on the Facilitated Post-Perceptual Processing

No evidence contradicting the argument that the occipito-temporal N250 is a robust index of familiarity with a face had been detected in the present research (Tanaka et al., 2006; Kaufmann et al., 2009; Gosling & Eimer, 2011; Andrews et al., 2017; Wiese et al., 2019c). Current ERP findings additionally confirm the assumption that familiar and unfamiliar faces are processed differently (Johnston & Edmonds, 2009; Ramon & Gobbini, 2017), as even though the overall strength of familiarity effects did vary with priming, at no point from 200ms onward did the amplitudes elicited by the two target categories overlap.

Most importantly, all experiments distinguished between a domain-specific and a domain-general stage of processing detected in the 200-400ms time window, previously identified as the domain-specific N250 familiarity effect (Gosling & Eimer, 2011; Wiese et al., 2019c; Wiese et al., 2022b; Wiese et al., 2023). The use of cross-domain (Experiment 1 and 2) together with within-domain (Experiment 3) priming allowed us to more precisely differentiate between the face processing stages previously investigated by comparing the ERP responses to familiar and unfamiliar faces.

In Experiment 3/Repetition Priming, domain-specific priming (i.e. face stimuli preceding face targets) was used and had a significant influence on the familiarity effect detected in the 200-400ms time window, which was expected given the pre-existing assumptions that the N250 familiarity effect reflects the processing of long-term perceptual representations stored for familiar faces and unavailable for unfamiliar faces (Bruce & Young, 1986; Gosling & Eimer, 2011; Wiese et al., 2019c; Wiese et al., 2022b). Meanwhile, only the ERP amplitudes restricted to the 200-300ms time window remained unaffected by domain-general priming in Experiment 1/Self-Priming and in Experiment 2/Associative Priming, with a priming effect elicited from 300-400ms - a time frame previously associated with a domain-specific stage of face processing (Wiese et al., 2022b; Wiese et al., 2023).

The enhanced familiarity effect observed for *primed* rather than *unprimed* conditions from 300-400ms in Experiment 1/Self-Priming and from 500-600ms in Experiment 2/Associative Priming implies that the difference between how familiar and unfamiliar faces are processed can be regulated by pre-activating domain-general representations held for personally familiar *people* by using name primes. This is because priming has been found to modulate the activity of units within the face recognition system (e.g. Burton et al., 1990), showing that the neural responses to familiar people could be influenced through bottom-up input to modality-independent units (Experiment 1; e.g. Calder & Young, 1996; Jemel et al., 2005; Wiese et al., 2017) but also through their top-down activation from units holding semantic or conceptual knowledge shared between closely associated familiar people (Experiment 2; e.g. Young et al., 1988; Schweinberger, 1996; Vladeanu et al., 2008; Wiese, 2011).

In Experiment 1, the interaction of the familiarity effect with cross-domain priming was observed earlier than expected (300-400ms), providing evidence against the argument that the N250 familiarity effect reflects the processing of familiar face representation from 200-400ms after stimulus onset. Consequently, we may argue that a familiar name had pre-activated a related person representation closer to the threshold for subsequent identity recognition once a target face was seen, which enhanced the difference between the ERP waveforms to unfamiliar and familiar faces. This would suggest that the ERP correlates of familiarity detected from 300ms onwards have their locus at the domain-general PINs, rather than the domain-specific representations held for familiar *faces* which would have not been influenced by name primes (Burton et al., 1990; Calder & Young, 1996; Jemel et al., 2005; Wiese et al., 2022b).

A similar interaction of familiarity and associative priming was detected in a later time frame (500-600ms) in Experiment 2. This effect quite clearly overlapped with the SFE and was most prominent over the right hemisphere, which points at a close link of this effect to face processing (Wiese et al., 2022b). This expanded on the results of Experiment 1, demonstrating that the SFE can be enhanced by priming the domain-general representations of familiar people with top-down input (e.g. the semantics pool in the IAC model; Burton et al., 1990) shared between related identities and accessed via name primes. This should move the associated PINs closer to the activation threshold necessary for the recognition of a target identity, potentially due to facilitated access to identity-specific person knowledge (Burton et al., 1990; Burton et al., 1999; McNeill & Burton, 2002; Wiese et al., 2017). Although it has been questioned whether the representations of two closely related individuals (i.e. the prime and target identities) can be active at the same time rather than inhibited, close associative links between individuals have been repeatedly shown to facilitate person recognition (Burton et al., 1990; Stone, 2008; Wiese & Schweinberger, 2015; Wiese et al., 2017). This study suggests that spreading activation from top-down units to the related PINs may be possible, moving these closer to threshold for recognition and decaying shortly, as proven by an immediate nature of associative priming (Calder & Young, 1996; Schweinberger, 1996, McNeill & Burton, 2002). Nonetheless, the methodology used in the present study made it impossible to disentangle the influence of co-occurrence and semantic relatedness on the activation of identity-specific representations each participant gained from subjective real-life experiences (Stone, 2008; Wiese, 2011; Wiese & Schweinberger, 2008, 2015). It can still be argued that both forms of input to related person representations had partially mediated the SFE, demonstrating that it may be associated with a level of conceptual processing (Schweinberger, 1996; Schwartz & Yovel, 2016; Wiese et al., 2022b).

Nonetheless, the interpretations discussed above are not entirely conclusive. The influence of priming on familiarity effects shows a topographical overlap in the right hemisphere across Experiment 1 and 2, but occurs at distinct time points. Associative priming may be delayed in modulating the processing of familiar faces, as rather complex neural pathways could be engaged to enhance the activity of closely related person representations, in comparison to the relatively more straightforward impact of cross-domain identity repetition (Bruce & Valentine, 1986; Burton et al., 1990; Young et al., 1994; Calder & Young, 1996). Alternatively, it is possible that the familiarity and ERP priming effects have been predominately modulated by the prediction of a specific response to a viewed face rather than conceptual processing, as will be discussed in the following section of the work (see Chapter 6.2)

Experiment 3 contributed additional contrasting evidence, demonstrating that the N250 familiarity effect and the SFE are substantially reduced when measured in the *primed* compared to the *unprimed* conditions. An increased N250 effect was predicted, with the domain-specific prime strengthening the FRU-PIN connection while enhancing the PIN activity and eliciting target recognition (Burton et al., 1990). However, this assumption cannot be confirmed with the present findings. These are puzzling, as the repetition effect has been reliably found in prior ERP research (Herzmann et al., 2004; Schweinberger et al., 2004; Neumann & Schweinberger, 2008; Wiese et al., 2017; Wiese et al., 2019b). As such, the familiarity effect has likely been diminished in the identity repetition trials due to the methodological factors specific to this experiment. We argue that this outcome resulted from the repeated presentations of unfamiliar faces, leading to the formation of structural representations in participants' memory. Previous research has demonstrated that these may emerge even under conditions of relatively high attentional load (Burton et al., 2011; Neumann et al., 2011; Tacikowski et al., 2011; Zimmerman & Eimer, 2013; Andrews et al., 2017). Therefore, the frequent repetition of two previously unknown faces had likely resulted in a N250r-like modulation observed for primed and unprimed unfamiliar faces, while the predicted N250r was likely diminished because of the adaptation to the repeated presentations of the same familiar identities (Lewis & Ellis, 2000; Grill-Spector et al., 2006). These could have had an unexpected influence on the neural responses to repeated familiar and unfamiliar faces, potentially resulting in a reduced difference between these.

Still, we can argue that the N250 and SFE detected in this study can serve as additional proof that personally familiar faces have robust representations in our memory, the activation of which can be distinguished from the ERP amplitudes elicited by unfamiliar faces, even if priming is introduced as an additional stimulus likely modulating the participants' neural activity (Tanaka et al., 2006; Andrews et al., 2017; Wiese et al., 2019b; Wiese et al., 2022b).

6.2 Evidence for the influence of Target Category Prediction on the Familiarity Effect

Critical evidence from this study found that self-priming, associative priming and repetition priming all had a significant influence on the waveforms elicited by familiar *and* unfamiliar faces. A clear P3-like effect was detected in the post hoc analysis of Experiment 1 and 2, with more negative amplitudes for unprimed than primed faces, which was especially prominent over the right occipito-temporal regions. Additionally, the SFE has been significantly reduced within an overlapping time window, particularly when compared to previous research. Notably, this effect was observed without the usual second peak which normally follows the N250 familiarity effect (Wiese et al., 2019c; Wiese et al., 2022a; Wiese et al., 2022b).

Previously, the N400 had been either smaller or non-existent when priming unfamiliar faces compared to familiar faces (Schweinberger et al., 1995; Herzmann et al., 2004). The N400 for associative priming had also been enhanced by learning faces based on shared semantics and co-occurrence, suggesting an essential role of person knowledge in eliciting this ERP effect (Vladeanu et al., 2006; Wiese & Schweinberger, 2015). However, unfamiliar faces are not associated with long-term memory representations or much identity-specific knowledge, which is why their neural processing should not be largely influenced by identity repetition (both within- and cross-domain) or by associative priming (Bruce & Young, 1986; Burton et al., 1990; Schweinberger & Burton, 2003). Therefore, the present findings suggest that the difference between primed and unprimed faces has been influenced by the prediction of a specific response to the target (familiar/unfamiliar) dependent on the context established by the prime.

According to the predictive coding assumptions, the context provided by the prime could have been used to make predictions about the environment by engaging higher-level processing, which are then matched with actual sensory input, with any incongruence (mismatch) generating a prediction error and facilitating neural activity (Friston, 2012; Amado et al., 2018; Trapp et al., 2018). Summerfield et al. (2008) argued that a reduced prediction error (PE) corresponds with repetition suppression; the diminished neural activity often detected with the fMRI when a stimulus is repeated and therefore more expected. Researchers found that repetition suppression is driven by top-down input from our expectations about the environment, decreasing when the prediction does not match the actual sensory input. In turn, as discussed in the Introduction, Amado et al. (2018) used the fMRI adaptation (fMRIa) BOLD signal to examine the neural underpinnings of self-priming. Researchers found that the activity of occipito-temporal face sensitive regions (the FFA and the OFA) was lowered when the prime and target were congruent rather than incongruent on their identity, showing repetition suppression was likely modulated by target expectancy. In line with that study, the present research has also used a cross-domain repetition priming paradigm (Chapter 3), where the prime and target could either be congruent or not. It is possible that the P3-like amplitudes were modulated by priming in both categories (familiar/unfamiliar), due to a mismatch of the visual input (i.e. the target) with the top-down prediction based on a pre-established context (Polich, 2007).

Although such interpretations have been explored with fMRI research, it is difficult to relate these back to the present ERP findings. In lexical research, Steinhauer et al. (2017) found that the strength of the N400 effect to semantically related vs unrelated words depends on whether these are consistent with the context in which they were presented (e.g. a list of other meaningful words). Similarly, Lau et al. (2013) observed that the N400 was diminished when semantically related words were presented in a context which was informative of the target category. Researchers have instead noted an increased P3 effect to unexpected target stimuli when these were task-relevant (i.e. participants were instructed to respond to a specific category). As pointed out in Chapter 3 and 4, van Vliet et al. (2014) found that a P3 effect, rather than a N400, was elicited when the participants were required to make a speeded response ("are the prime and target related or not?") to either semantically associated or unrelated word pairs, even when the primes likely did not provide context informative of an upcoming response to the target. In the present study, a familiar/unfamiliar button press (see Chapter 2) was the specific task given to the participants, making their predictions directly relevant to the explicit demands of the experiment (Reed et al., 2022). It still required them to process the familiarity of both stimuli, but with the goal of determining an accurate response to each target.

In relation to this, prior ERP studies have investigated the P3b effect which had been related to the updating of a predicted context, engaging top-down processing from working memory and selective attentional resources to specific task demands (Polich, 2007). This has been explored in face recognition research mostly by manipulating *emotional* context in which a face is processed (i.e. positive/negative valence), rather than the predicted target *familiarity* response category during ERP measurements (e.g. Wieser et al., 2014). For example, Lin et al. (2015) used cues which elicited expectations regarding the expression of a target face (fearful/neutral) that could be congruent or incongruent with the actual target. Incongruent faces elicited a larger P3 which has been additionally modulated by the attentional load during cue processing. Therefore, any substantial inconsistency between a prime and the incoming target would have modulated the ERP amplitudes elicited by both familiar *and* unfamiliar faces, especially because the task in the present series of experiments explicitly required a specific categorical response (Polich, 2007).

Moreover, it is important to highlight that this effect relatively closely coincided with the reduced *SFE* which had been the main focus of this investigation. Although the extent to which the SFE diminished is not fully evident when only looking at the current findings, these show quite a stark contrast with the strength of this effect obtained by prior research. Wiese et al. (2019c), who also compared the amplitudes elicited by personally familiar and unfamiliar faces (see Figure 2), found the size of the SFE equalled ~4 μV. Similarly large SFE peaks were also observed by Wiese et al. (2022a) and Wiese et al. (2022b), which could be easily distinguished from the lower peak of the N250. Meanwhile, the present series of experiments detected the observed SFE peak reached a maximum of ~3 μV and was notably reduced in comparison to the prominent N250. Importantly, the SFE was previously reliably elicited in conditions where explicit recognition of familiarity was task-irrelevant (e.g. in a butterfly-detection task while passively viewing faces; Wiese et al., 2019c), and was not strongly influenced by whether or not recognition is explicitly required (Wiese et al., 2022a). It was also the strongest in conditions where highly variable face images are used, which has been the case in the present study (Wiese et al., 2022a). Therefore, neither the task or the stimuli used in the present study are likely factors underlying its decreased strength. However, a similarly reduced, yet still significant SFE has been observed in a task where the participants' attention was engaged in a demanding task during the presentation of face stimuli (Wiese et al., 2019b). This has been attributed to the cognitive load required by the task and interfering with the sustained activation elicited by familiar faces, which was not the case for the relatively automatic N250.

Building on this, it is important to consider that the prediction of target category reflected by the priming effect could significantly diminish the SFE. This process is likely cognitively demanding, establishing the expectation based on the given context and evaluating any incongruence between it and the actual familiarity response required by the target (Brennen & Bruce, 1991; Polich, 2007; Amado et al., 2018). This post hoc explanation is in line with previous findings which detect reductions in the SFE related to the attentional load necessary for a specific task (Wiese et al., 2019b), potentially interfering with its functional underpinnings. Both priming and the SFE may reflect post-perceptual processes essential to interpret incoming stimuli in preparation for potential interactions with the environment (Wiese et al., 2023), with the primes providing context (e.g. familiarity) which needs to be processed and integrated before interacting with another person/responding to a specific stimulus, and thus engaging attention. However, since the SFE has also been enhanced by self- and associative priming in specific time windows (see Chapter 6.1), priming could still modulate how familiar and unfamiliar faces are processed, reflecting facilitated access to identity-specific knowledge associated with the domain-general representations of familiar people (Burton et al., 1990).

6.3 Experimental Limitations

While the evidence obtained from within-domain and cross-domain priming of familiar and unfamiliar faces found significant effects of familiarity and the prediction of a response to the target, several limitations of the present study must be acknowledged before drawing definitive conclusions.

As acknowledged when discussing Experiment 3, any changes in the priming effect (unprimed – primed faces) related to the repetition of unfamiliar faces were likely due to an influence of learning. Even though this can inform future research into how quickly more image-invariant representations of faces can be built from naturalistic face stimuli (Tanaka et al., 2006; Kaufmann et al., 2009; Zimmerman & Eimer, 2013; Andrews et al., 2017; Ritchie & Burton, 2017), it was an unexpected effect which emerged without the experimenters' control. This may have biased the relevant evidence, potentially influencing the familiarity effects measured. A potential impact of learning on the amplitudes elicited by faces in Experiment 1 and 2 cannot be excluded, however, it was not explicitly detected in the ERP findings. This should be considered in any future research, executing caution if varied unfamiliar stimuli depicting a limited number of identities (i.e. only two) are used to measure any effects of familiarity.

In addition, a potential issue could be related to the use of *name* primes in Experiment 1 and 2. Although cross-domain priming with the use of names has been widely applied throughout research and acknowledged as a significant pathway to access the domain-general PINs (Burton et al., 1990; Calder & Young, 1996; Schweinberger, 1996; Pickering & Schweinberger, 2003; Jemel et al., 2005; and more), it may have confounded some of the participants' neural or behavioural responses and has met some prior criticism (see Schweinberger et al., 2001). It could be possible that a prime categorized as *unfamiliar* could have been a name associated with another potentially familiar person to the participant, automatically activating related representations and confounding their response. However, we can also argue that the use of *personally familiar* names in the context of this study likely decreased the potential impact of this confound, as it is very unlikely the participants would forget or misattribute the name of their relatives or close friends. We have additionally ensured that the names used for each pair of participants were not the same to avoid priming the recognition of a familiar and unfamiliar face at the same time.

Finally, a key factor to consider is that the present study used a range of naturally varying ("ambient") images, allowing the research to examine the ERP correlates of person recognition with an ecologically valid procedure, mirroring how faces are encountered in everyday scenarios (Andrews et al., 2015; Burton et al., 2016; Kramer et al., 2018; Wiese et al., 2019c). Even though this approach was predominately advantageous and allowed for clear measurements of realistic face processing, it also significantly reduced the amount of control the researchers had over the stimuli that were used. This could have resulted in systematic differences between the images used influencing the related ERP measurements, e.g. in response to unique characteristics of the images used in different trials. Nonetheless, early ERP components, including the P1 (~80 – 100ms after stimulus onset) and the N170, are generally sensitive to low-level visual characteristics of images (e.g. luminance, spatial frequency or contrast; Nakashima et al., 2008). Our analysis does not reveal notable changes at these time points which would be reflected by any systematic differences between the features of chosen images. Still, it is essential to note that each set of images used during every trial was associated with a large degree of natural variability, possibly eliminating any *systematic* differences that would be noticeable when comparing specific experimental conditions (Wiese et al., 2022b). We have additionally attempted to minimize the potential influence of this limitation on the present results by using the same face IDs for each pair of participants, which balanced stimuli across familiarity conditions within each pair (see Chapter 2.2; Wiese et al., 2023). To ensure that these extraneous variables are reduced with even more certainty, future research could additionally follow the procedure of, for example, Schweinberger et al. (1995) or Wiese et al. (2022b) and match the images submitted by the participants based on their features (e.g. age, hairstyle, gender), which has not been done in the present study. Nonetheless, using ambient face stimuli tailored to individual participants, rather than the same set of strictly controlled or identical photographs of faces, is specifically suited for the purposes of the present research (Andrews et al., 2017; Ritchie & Burton, 2017; Wiese et al., 2019c). It would be highly challenging to measure the neural correlates of close personal familiarity and its processing in real-life situations with the same set of face images used for every participant, which is why the current approach is still considered most appropriate.

6.4 Directions for Future Research

Despite the insights provided by the current dissertation, several areas remain unexplored and provide promising directions for future research. These could advance our understanding of the neural underpinnings of familiar face recognition and address the limitations present in the current study, especially when attempting to disentangle the processing of perceptual representations held for known faces from the more post-perceptual integration of conceptual *person* knowledge.

First, there remains a significant question of whether priming familiar and unfamiliar faces engaged automatic category prediction or conscious, strategic processing. The relatively long SOA (800ms) used in each experiment could suggest a potential role of strategic processing in eliciting the priming effects produced for both target categories (Neely, 1977; Jemel et al., 2005; Wiese, 2011; Stevenage et al., 2014). The predictive value of the prime was not manipulated and there was an equal chance that the target will be either familiar or unfamiliar in each trial. However, expectancy-based processing may still be possible, as only *four different identities* had been used and there was always a 50% chance the predicted outcome will be correct. To examine this, future research could manipulate the SOA to reduce the potential influence of expectancy-based processes and verify whether the influence of priming on the familiarity effect is still significant (Posner & Snyder, 1975; Becker, 1980; Wiese, 2011). In turn, any priming research using a speeded familiarity decision task where primes may be congruent or incongruent with the targets should consider the possibility of detecting a P3-like effect rather than the expected N400 (van Vliet et al., 2014). The importance of continually using both; familiar and unfamiliar face stimuli should also be emphasized, as this approach made it possible to detect the significant influence of priming on how faces without associated long-term memory representations are processed in comparison to those likely related with in-depth person knowledge (Schwartz & Yovel, 2016). Consequently, further research is needed to examine the potential contribution of predictive processes in eliciting the well-established priming effects.

Secondly, the findings from the Repetition Priming study have likely been skewed by a diminished difference between pre-experimentally familiar and unfamiliar faces. In addition, the lack of the expected N250r and the P3-like effect being restricted only to familiar faces are another puzzling outcomes which make concrete conclusions related to the contribution of this experiment to the dissertation problematic. To verify the role of learning from stimulus variability and test how learning, but also habituation to familiar identities, develops throughout the time course of a repetition priming study, it could be beneficial to compare the ERP responses to familiar and pre-experimentally unfamiliar faces in each experimental block (Burton et al., 2011; Jenkins et al., 2011; Koca & Oriet; 2023; Popova & Wiese, 2023). Additionally, to make learning more demanding and potentially reduce any influence of adaptation and ceiling-level activation to familiar face representations which could diminish the N250r, additional familiar and unfamiliar identities could be introduced in similar procedures. A replication of the specific experiment would be beneficial to uncover whether any methodological factors have influenced the lack of differentiation between neural responses to immediately primed vs unprimed familiar identities (Bruce & Young, 1986).

Finally, we highlight there is still a significant need to localize the SFE within the face recognition system and describe its related functions. The current findings indicate that the locus of the SFE is at the domain-general person representations, reflecting post-perceptual processes which can be modulated by the cognitive processes related to the processing of prime/target familiarity for a specific response to a target (Wiese et al., 2019b; Wiese et al., 2023). However, it would be interesting to examine the extent to which it can be influenced by the processing of other relevant categorical information related to familiar face recognition or potentially facilitated access to PINs (Burton et al., 1990). Incorporating, for example, primes from different stimulus modalities than names (e.g. *voices*; O'Mahony & Newell, 2012) or priming the access to specific conceptual categories via within-domain associative priming (Jemel et al., 2005) could further inform us how far does the SFE reflect access to identity-specific information about familiar people. Moreover, to verify whether the task-relevant prediction of a response to the target is what uniquely contributed to the corresponding changes in the SFE, further research could use a different cognitive task during priming, e.g. explicitly naming the target person, deciding whether the prime and target depict the same person (van Vliet et al., 2014) or two individuals associated in a specific category (e.g. "do the two people share their nationality/occupation?") , or a more passive butterfly detection task (Wiese et al., 2022a). Requiring different responses to the familiar/unfamiliar faces could further inform us whether the SFE is modulated by the processing of contextual information considered essential for an interaction with our environment, such as identity-specific knowledge about an encountered person (Wiese et al., 2023).

6.5 Conclusions

To conclude, this dissertation provides electroencephalographic evidence which compare the neural underpinnings of self-priming, associative priming and repetition priming to examine whether the N250 familiarity effect and the subsequent SFE are modulated by the facilitated access to perceptual and post-perceptual representations of familiar people, or by the prediction of an upcoming categorical response to the target (familiar/unfamiliar) once the familiarity of both stimuli is processed. The work uniquely contributes to the existing research on the SFE and provides additional information about the functional underpinnings of this effect.

Altogether, it was confirmed that the SFE is a clear index of familiarity with a face which can be reliably elicited by *personally* familiar faces. We also discovered that the SFE can be modulated by the cognitive processes necessary to evaluate the category of stimuli and is partially independent from the earlier N250 familiarity effect. The N250 (200-300ms) likely reflects the comparably more robust activation of image-invariant representations of familiar faces which can be acquired from repeated exposure to different views of the same person's face (see Experiment 3; Kaufmann et al., 2009; Burton et al., 2016; Andrews et al., 2017) and is not significantly dependent on the cognitive demands of priming. Nonetheless, this study highlights the need to investigate the neural underpinnings of the N250 more carefully within the pre-established time window (200-400ms; Gosling & Eimer, 2011; Wiese et al., 2019c; Wiese et al., 2022b), as it detected a clear shift from within- to cross-domain processing stages in this short time frame. Cross-domain priming was shown to additionally facilitate bottom-up and top-down access to person-specific representations which was reflected by the enhanced familiarity effects found within restricted time frames during Experiment 1 and 2.

Notably, these findings do not exclude the importance of identity repetition and strong associative relationships in facilitating access to the domain-general representations of people through the relevant priming paradigms. However, incorporating priming when examining the distinct neural responses to familiar *and* unfamiliar faces provides a valuable measure of the extent to which such domain-general representations are actually accessed and reflected in the changing ERP amplitudes we observe during related experimental manipulations. In turn, we propose that the SFE could be additionally influenced by the processing of context provided by the prime and attempting to predict the incoming response to the target relevant for the specific task used, potentially reflective of our preparation for a potential interaction with the environment.

Appendices

Appendices Table of Contents

Appendix A

P Number	P Code	Gender	Age	LH Dominance	RH Dominance	Laterality Quotient	Handedness
1	PR28	F	20	0	24	100	**R**
2	IR16	M	22	1	17	89	**R**
3	LE10	F	22	4	19	65.22	**R**

4	EL04	F	22	0	24	100	**R**
5	SH22	F	22	14	5	-47.37	**L**
6	KA10	F	21	0	12	100	**R**
7	BI04	F	22	0	15	100	**R**
8	YV15	M	21	2	15	86.67	**R**
9	ME05	F	22	1	11	83.33	**R**
10	GE21	F	21	2	12	71.43	**R**
11	CR31	F	22	5	19	58.33	**R**
12	IN20	F	20	3	14	64.71	**R**
13	FI23	F	19	1	18	89.47	**R**
14	I01	F	21	0	12	100	**R**
15	MI04	F	19	3	9	50	**R**
16	HE18	F	20	0	16	100	**R**
17	LI09	F	21	0	12	100	**R**
18	AM15	M	20	12	3	-60	**L**
19	ME15	F	21	4	12	50	**R**
20	AN05	M	24	1	15	87.5	**R**

Participant demographics and handedness quotient for Experiment 1

Appendix B

Repeated-measures ANOVA main and interaction effects for exploratory statistics for Experiment 1.

ERP	Effect	df	*F*	*p*	η^2p
Site, hemisphere, familiarity and priming effects from 200-300ms					

site	(1,19)	20.77	<.001*	.522
hemisphere	(1,19)	0.06	.816	.003
familiarity	(1,19)	95.99	<.001*	.835
priming	(1,19)	4.67	.044*	.197
site * hemisphere	(1,19)	2.67	.119	.123
site * familiarity	(1,19)	4.84	.040*	.203
hemisphere * familiarity	(1,19)	7.99	.011*	.296
site * hemisphere * familiarity	(1,19)	0.00	.976	.000
site * priming	(1,19)	3.29	.085	.148
hemisphere * priming	(1,19)	1.32	.264	.065
site * hemisphere * priming	(1,19)	0.38	.547	.019
familiarity * priming	(1,19)	0.02	.882	.001
site * familiarity * priming	(1,19)	2.11	.163	.100
hemisphere * familiarity * priming	(1,19)	1.43	.246	.070
site * hemisphere * familiarity * priming	(1,19)	1.20	.286	.060

Site, hemisphere, familiarity and priming effects from 300-400ms

site	(1,19)	44.97	<.001*	.703
hemisphere	(1,19)	1.42	.248	.070
familiarity	(1,19)	67.72	<.001*	.781
priming	(1,19)	0.04	.842	.002
site * hemisphere	(1,19)	1.13	.301	.056
site * familiarity	(1,19)	0.60	.449	.030
hemisphere * familiarity	(1,19)	4.82	.041*	.202
site * hemisphere * familiarity	(1,19)	0.28	.605	.014
site * priming	(1,19)	0.05	.828	.003
hemisphere * priming	(1,19)	12.10	.003*	.389
site * hemisphere * priming	(1,19)	0.43	.519	.022
familiarity * priming	(1,19)	3.21	.089	.145
site * familiarity * priming	(1,19)	1.04	.321	.052

hemisphere * familiarity * priming	(1,19)	4.53	.047*	.193
site * hemisphere * familiarity * priming	(1,19)	0.14	.708	.008

Site, hemisphere, familiarity and priming effects from 400-500ms

site	(1,19)	41.87	<.001*	.688
hemisphere	(1,19)	3.17	.091	.143
familiarity	(1,19)	23.95	<.001*	.558
priming	(1,19)	7.51	.013*	.283
site * hemisphere	(1,19)	0.00	.951	.000
site * familiarity	(1,19)	1.51	.234	.074
hemisphere * familiarity	(1,19)	0.05	.826	.003
site * hemisphere * familiarity	(1,19)	5.51	.030*	.225
site * priming	(1,19)	5.59	.029*	.227
hemisphere * priming	(1,19)	3.73	.069	.164
site * hemisphere * priming	(1,19)	0.18	.677	.009
familiarity * priming	(1,19)	0.27	.608	.014
site * familiarity * priming	(1,19)	0.03	.874	.001
hemisphere * familiarity * priming	(1,19)	1.35	.260	.066
site * hemisphere * familiarity * priming	(1,19)	1.74	.203	.084

Site, hemisphere, familiarity and priming effects from 500-600ms

site	(1,19)	15.29	<.001*	.446
hemisphere	(1,19)	4.47	.048*	.191
familiarity	(1,19)	54.02	<.001*	.740
priming	(1,19)	0.96	.339	.048
site * hemisphere	(1,19)	0.02	.878	.001
site * familiarity	(1,19)	1.27	.274	.063
hemisphere * familiarity	(1,19)	0.97	.338	.048
site * hemisphere * familiarity	(1,19)	4.56	.046*	.194
site * priming	(1,19)	4.34	.051	.186
hemisphere * priming	(1,19)	0.65	.429	.033
site * hemisphere * priming	(1,19)	0.45	.511	.023
familiarity * priming	(1,19)	0.50	.488	.026
site * familiarity * priming	(1,19)	0.04	.849	.002
hemisphere * familiarity * priming	(1,19)	0.26	.626	.013
site * hemisphere * familiarity * priming	(1,19)	3.49	.077	.155

Note: Asterisks in the *p* column denote a significant effect ($p < .05$).

Appendix C

Participant demographics and handedness quotient for Experiment 2

P Number	P Code	Gender	Age	LH Dominance	RH Dominance	Laterality Quotient	Handedness
1	CR31	F	23	5	17	54.55	**Right**
2	JA11	F	20	3	14	64.71	**Right**
3	KA05	F	22	1	16	88.24	**Right**
4	HE18	F	20	0	16	100	**Right**
5	MA89	F	19	7	17	41.67	**Right**
6	KE09	F	19	4	18	63.64	**Right**
7	JU15	F	21	0	12	100	**Right**
8	HE01	M	20	2	18	80	**Right**
9	HE01	F	19	0	12	100	**Right**
10	BR27	M	20	10	3	-53.85	**Left**
11	EM09	F	21	0	12	100	**Right**
12	PO10	F	20	0	12	100	**Right**
13	AN09	F	22	4	15	57.89	**Right**
14	MI10	F	20	0	12	100	**Right**
15	HU02	F	20	6	12	33.33	**Ambidex.**
16	JU19	F	30	0	12	100	**Right**
17	CA21	F	21	2	17	78.95	**Right**
18	JO07	F	22	0	23	100	**Right**
19	JO31	F	26	0	15	100	**Right**
20	GE21	F	22	2	14	75	**Right**

Appendix D

Repeated-measures ANOVA main and interaction effects for exploratory statistics for Experiment 2.

ERP	Effect	df	*F*	*p*	η²p
Site, hemisphere, familiarity and priming effects from 200-300ms					
	site	(1,19)	18.54	<.001*	.494
	hemisphere	(1,19)	0.83	.374	.042
	familiarity	(1,19)	54.37	<.001*	.741
	priming	(1,19)	0.27	.606	.014
	site * hemisphere	(1,19)	0.35	.560	.018
	site * familiarity	(1,19)	2.37	.140	.111
	hemisphere * familiarity	(1,19)	16.88	<.001*	.470
	site * hemisphere * familiarity	(1,19)	0.05	.824	.003
	site * priming	(1,19)	0.41	.529	.021
	hemisphere * priming	(1,19)	0.14	.710	.007
	site * hemisphere * priming	(1,19)	1.75	.202	.084
	familiarity * priming	(1,19)	0.75	.399	.038
	site * familiarity * priming	(1,19)	0.04	.852	.002
	hemisphere * familiarity * priming	(1,19)	9.29	.007*	.328
	site * hemisphere * familiarity * priming	(1,19)	0.00	.948	.000
Site, hemisphere, familiarity and priming effects from 300-400ms					
	site	(1,19)	30.06	<.001*	.613
	hemisphere	(1,19)	0.08	.785	.004
	familiarity	(1,19)	57.45	<.001*	.751
	priming	(1,19)	5.02	.037*	.209
	site * hemisphere	(1,19)	2.49	.131	.116
	site * familiarity	(1,19)	0.80	.382	.040

hemisphere * familiarity	(1,19)	7.23	.015*	.276
site * hemisphere * familiarity	(1,19)	0.00	.955	.000
site * priming	(1,19)	1.55	.228	.075
hemisphere * priming	(1,19)	0.12	.735	.006
site * hemisphere * priming	(1,19)	0.00	.950	.000
familiarity * priming	(1,19)	0.35	.560	.018
site * familiarity * priming	(1,19)	0.05	.819	.003
hemisphere * familiarity * priming	(1,19)	5.47	.030*	.224
site * hemisphere * familiarity * priming	(1,19)	0.49	.492	.025

Site, hemisphere, familiarity and priming effects from 400-500ms

site	(1,19)	19.36	<.001*	.505
hemisphere	(1,19)	0.61	.445	.031
familiarity	(1,19)	51.98	<.001*	.732
priming	(1,19)	13.54	.002*	.416
site * hemisphere	(1,19)	2.55	.127	.118
site * familiarity	(1,19)	1.36	.259	.067
hemisphere * familiarity	(1,19)	0.70	.413	.036
site * hemisphere * familiarity	(1,19)	3.31	.085	.148
site * priming	(1,19)	3.91	.063	.170
hemisphere * priming	(1,19)	0.00	.961	.000
site * hemisphere * priming	(1,19)	0.01	.918	.001
familiarity * priming	(1,19)	0.23	.635	.012
site * familiarity * priming	(1,19)	0.02	.893	.001
hemisphere * familiarity * priming	(1,19)	6.80	.017*	.264
site * hemisphere * familiarity * priming	(1,19)	0.02	.905	.001

Site, hemisphere, familiarity and priming effects from 500-600ms				
site	(1,19)	12.08	.003*	.389
hemisphere	(1,19)	1.52	.233	.074
familiarity	(1,19)	47.08	<.001*	.712
priming	(1,19)	2.63	.122	.121
site * hemisphere	(1,19)	1.31	.267	.065
site * familiarity	(1,19)	2.67	.119	.123
hemisphere * familiarity	(1,19)	12.89	.002*	.404
site * hemisphere * familiarity	(1,19)	3.33	.084	.149
site * priming	(1,19)	2.26	.149	.106
hemisphere * priming	(1,19)	0.03	.870	.001
site * hemisphere * priming	(1,19)	0.44	.516	.022
familiarity * priming	(1,19)	3.32	.084	.149
site * familiarity * priming	(1,19)	0.09	.774	.004
hemisphere * familiarity * priming	(1,19)	5.49	.030*	.224
site * hemisphere * familiarity * priming	(1,19)	0.04	.840	.002

Note: Asterisks in the *p* column denote a significant effect ($p < .05$).

Appendix E

Participant demographics and handedness quotient for Experiment 3

P Number	P Code	Gender	Age	LH Dominance	RH Dominance	Laterality Quotient	Handedness
1	YO28	F	22	1	15	87.5	**Right**
2	PR16	M	25	0	24	100	**Right**
3	YA06	F	20	0	12	100	**Right**
4	BH24	F	20	3	13	62.5	**Right**
5	LI02	F	20	0	12	100	**Right**
6	DE02	F	20	1	17	88.89	**Right**
7	SU28	F	20	0	13	100	**Right**
8	10720	F	19	0	19	100	**Right**
9	HO28	F	19	0	13	100	**Right**
10	NO07	F	20	0	13	100	**Right**
11	FI121	F	21	4	17	61.9	**Right**
12	KI29	M	18	11	1	-83.33	**Left**
13	EL15	F	20	8	4	-33.33	**Left**
14	HU22	F	19	0	12	100	**Right**
15	FI18	F	19	1	16	88.24	**Right**
16	WE16	F	21	3	11	57.14	**Right**
17	MI10	F	20	2	22	71.43	**Right**
18	XI03	M	20	3	13	62.5	**Right**
19	GE21	F	22	2	14	75	**Right**
20	LU25	M	27	5	17	54.55	**Right**

Appendix F

Repeated-measures ANOVA main and interaction effects for exploratory statistics for Experiment 3.

ERP	Effect	df	*F*	*p*	η^2p
Site, hemisphere, familiarity and priming effects from 200-300ms					
	site	(1,19)	33.14	<.001*	.636
	hemisphere	(1,19)	1.94	.180	.093
	familiarity	(1,19)	98.10	<.001*	.838
	priming	(1,19)	5.78	.027*	.233
	site * hemisphere	(1,19)	2.82	.110	.129
	site * familiarity	(1,19)	4.41	.049*	.188
	hemisphere * familiarity	(1,19)	18.63	<.001*	.495
	site * hemisphere * familiarity	(1,19)	0.03	.863	.002
	site * priming	(1,19)	3.33	.084	.149
	hemisphere * priming	(1,19)	0.38	.548	.019
	site * hemisphere * priming	(1,19)	0.75	.396	.038
	familiarity * priming	(1,19)	11.38	.003*	.375
	site * familiarity * priming	(1,19)	0.19	.672	.010
	hemisphere * familiarity * priming	(1,19)	0.99	.333	.049
	site * hemisphere * familiarity * priming	(1,19)	1.56	.226	.076
Site, hemisphere, familiarity and priming effects from 300-400ms					
	site	(1,19)	28.25	<.001*	.598
	hemisphere	(1,19)	0.15	.702	.008
	familiarity	(1,19)	126.31	<.001*	.869
	priming	(1,19)	2.76	.113	.127
	site * hemisphere	(1,19)	0.05	.833	.002
	site * familiarity	(1,19)	4.95	.038*	.207

	hemisphere * familiarity	(1,19)	8.37	.009*	.306
	site * hemisphere * familiarity	(1,19)	0.80	.382	.040
	site * priming	(1,19)	10.94	.004*	.365
	hemisphere * priming	(1,19)	0.27	.607	.014
	site * hemisphere * priming	(1,19)	0.00	.960	.000
	familiarity * priming	(1,19)	6.39	.021*	.252
	site * familiarity * priming	(1,19)	0.00	.999	.000
	hemisphere * familiarity * priming	(1,19)	1.53	.232	.074
	site * hemisphere * familiarity * priming	(1,19)	0.01	.936	.000
Site, hemisphere, familiarity and priming effects from 400-500ms					
	site	(1,19)	17.02	<.001*	.472
	hemisphere	(1,19)	0.07	.794	.004
	familiarity	(1,19)	51.91	<.001*	.732
	priming	(1,19)	0.07	.793	.004
	site * hemisphere	(1,19)	0.70	.415	.035
	site * familiarity	(1,19)	1.49	.237	.073
	hemisphere * familiarity	(1,19)	0.00	.967	.000
	site * hemisphere * familiarity	(1,19)	3.79	.067	.166
	site * priming	(1,19)	9.85	.005*	.341
	hemisphere * priming	(1,19)	0.03	.862	.002
	site * hemisphere * priming	(1,19)	0.00	.987	.000
	familiarity * priming	(1,19)	5.40	.031*	.221
	site * familiarity * priming	(1,19)	0.45	.511	.023
	hemisphere * familiarity * priming	(1,19)	0.19	.667	.010
	site * hemisphere * familiarity * priming	(1,19)	0.04	.839	.002
Site, hemisphere, familiarity and priming effects from 500-600ms					

site	(1,19)	9.82	.005*	.341
hemisphere	(1,19)	0.98	.334	.049
familiarity	(1,19)	35.97	<.001*	.654
priming	(1,19)	7.26	.014*	.277
site * hemisphere	(1,19)	1.25	.278	.062
site * familiarity	(1,19)	1.88	.187	.090
hemisphere * familiarity	(1,19)	1.71	.207	.082
site * hemisphere * familiarity	(1,19)	3.36	.083	.150
site * priming	(1,19)	4.64	.044*	.196
hemisphere * priming	(1,19)	3.06	.096	.139
site * hemisphere * priming	(1,19)	0.47	.502	.024
familiarity * priming	(1,19)	11.07	.004*	.368
site * familiarity * priming	(1,19)	0.16	.690	.009
hemisphere * familiarity * priming	(1,19)	4.23	.054	.182
site * hemisphere * familiarity * priming	(1,19)	1.67	.211	.081

Note: Asterisks in the *p* column denote a significant effect ($p < .05$).

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