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Running Head: FACE PRIMING IN CONGENITAL PROSOPAGNOSIA

Covert face priming reveals a 'true face effect' in a case of congenital prosopagnosia.

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Abstract

Previous research indicates that individuals with congenital prosopagnosia (CP) fail to demonstrate significant priming from faces to related names in covert recognition tasks. The interpretation has been that CP precludes the ability to acquire face representations. In the current study we replicated this important finding, but also show a significant ‘true face effect’ in a CP patient, where face primes that matched the probe names facilitated reaction times compared to unrelated face primes. These data suggest that some individuals with CP may possess degraded face representations that facilitate the priming of a person’s identity, but not semantic associates.

Key words: congenital prosopagnosia, face recognition, face priming, covert recognition, face representations

Introduction

Lesions to the fusiform gyrus can result in prosopagnosia- a disorder in which patients have a profound difficulty recognizing familiar faces (Damasio, Tranel, & Damasio, 1990). These patients are described as having acquired prosopagnosia (AP) because their impairment in face recognition results from a brain injury. In contrast, several recent studies have described individuals with *congenital* prosopagnosia (CP). These individuals can have profound face recognition deficits in the absence of brain damage or other neurological impairments[1].

Although individuals with AP may fail to recognize faces overtly, research suggests that at least some of these patients may still possess covert knowledge of familiar faces (for a review see Schweinberger & Burton, 2003). One means of demonstrating such covert knowledge involves semantic priming where faces serve as the prime. Specifically, some patients with AP are faster to classify a name as famous if it is preceded by the picture of a person bearing some known relation to that name, compared to an unrelated, or unknown person (Young, Hellawell, & De Haan, 1988). Burton and colleagues (Burton, Young, Bruce, Johnston, & Ellis, 1991; Schweinberger & Burton, 2003) have suggested that covert recognition abilities in AP depend on the same system as normal face recognition. Specifically, this model (Figure 1) assumes that patients with AP may still be able to encode *some* of the visual input from the face, but the connection strengths between face recognition units (FRUs) and person identity nodes (PINs) are decreased such that activation cannot reach a sufficient threshold to result in overt recognition. However, input from the FRUs may still result in sub-threshold activation of PINs which could result in covert, but not overt recognition of the face. Furthermore, the sub-threshold activation

[1] We use the term congenital prosopagnosia to refer to such cases. This differs from the more general term ‘developmental prosopagnosia’ which encompasses individuals with CP, as well as those individuals with prosopagnosia resulting from early childhood brain damage or neurological impairment (see Behrmann & Avidan, 2005; Temple, 1992).

of a PIN would also result in activation of semantic information units (SIUs) associated with the PIN that would then *back-activate* other PINs that are semantically associated with that person. This would enable the presentation of a face that is not recognized overtly to prime the identity of other individuals associated with that individual covertly.

--Insert Figure 1 here--

Previous studies examining face-name priming in CP have failed to find any evidence of covert recognition (Barton, Cherkasova, & Hefter, 2004; De Haan & Campbell, 1991)[2]. Generally, these results have been interpreted as evidence that CP precludes the ability to acquire face representations. Importantly, the results from the current study indicate that some individuals with CP may possess degraded face representations that enable identity priming, but not semantic priming.

Methods

Participants

In the current investigation we tested MA, an individual with CP. MA is a right handed, 22 year old female senior undergraduate student. She has no history of stroke, head injury, episodes of epilepsy, or any other disorder. She recalls having a lifelong difficulty recognizing or identifying family, friends and colleagues from their faces. She also reports difficulty recognizing actors and actresses in films. However, she reports that context vastly improves her

[2] Although Bentin and colleagues (Bentin, Degutis, D'Esposito, & Robertson, 2007) observed covert recognition of emotional expression for faces in a case of CP, they failed to find evidence of facilitation from congruent faces in a forced choice face-name matching task. The results of Bentin and colleagues are consistent with those of Jones and Tranel (2001) who observed normal skin conductance responses to familiar faces in a case of developmental prosopagnosia.

ability to identify people. For example, if she is expecting to meet someone in a particular place, she can usually recognize them on the basis of such things as voice, gait, clothing, hairstyle or even pets (she once reported that she will recognize her dog before she recognizes that her mother is the person walking it).

In order to assess MA's visual recognition abilities we tested her and ten undergraduate control participants on a series of old/new discrimination tasks involving greyscale images of unfamiliar faces, cars, guns, houses or tools (for details see Duchaine & Nakayama, 2005). During the study phase participants were presented with ten target stimuli for three seconds per stimulus. The ten stimuli were shown twice. During the test phase, participants were presented with 50 stimuli one at a time and were asked to respond whether the test stimulus was "old" or "new". Of these 50 stimuli 20 were target stimuli (the ten targets, each presented twice) and 30 were new foils.

In a separate session we tested MA and 10 control participants on famous face identification. MA and controls were presented with 34 gray scale images of the faces of famous actors, athletes, musicians, and politicians (faces appeared on a white background and were edited to remove ears and hair). The famous faces were presented sequentially for an unlimited duration and participants were asked to identify each individual. A face was correctly identified if the name of the person was provided, or the participant provided accurate biographical details. The results of the old/new discrimination tasks and the famous faces test for MA and controls are presented in Table 1. The combined results indicate that MA's visual recognition deficit is specific to faces. Specifically, she is selectively impaired at discriminating unfamiliar faces and identifying famous faces.

--Insert Table 1 here--

In the current study we tested MA and a separate group of 13 healthy senior undergraduate students (11 female, 12 right handed; mean age=23yrs, SD=3.2) from the University of Waterloo. All participants provided informed consent prior to participating in the experiment in accordance with the Helsinki Declaration. The experimental protocol was approved by the Office of Research Ethics at the University of Waterloo.

Apparatus and Procedure

Control participants each completed a face-name, and a name-name priming task which were run in separate blocks. To ensure that any null outcomes in the priming tasks were not due to lack of power, MA completed each priming task 3 times in separate testing sessions (one initial session, two sessions 1 year later). Participants always completed the face-name priming task prior to the name-name priming task. The priming tasks were modeled after those developed by Young and colleagues (Young et al., 1988). In this task the standard finding is that participants demonstrate a priming effect where RTs for famous/non-famous judgments are faster when the face prime and name probe are semantically related relative to when the prime is unrelated to the probe. The famous face-name pairs used in the current study consisted of actors, actresses, politicians, singers, and athletes that were well known to Canadian undergraduate students and MA[3].

Our face priming tasks included seven different trial conditions, however only the first 3 conditions were important for indexing priming. The conditions were: 1) Famous face-related name; 2) Famous face-correct name. 3) Famous face-unrelated famous name. The remaining conditions were used to balance the design of the priming tasks to ensure an equal proportion of

[3] This was independently verified in a separate group of undergraduate students and MA prior to the current study.

famous and non-famous primes and probes were presented. The remaining conditions were: 4) Famous face-non-famous name; 5) Non-famous face-congruent name; 6) Non-famous face-famous name; 7) Non-famous face-non-famous name. There were 21 prime-probe pairs in each condition. The name priming tasks were identical except that name primes were used instead of faces. Name primes were in lower case, name targets on which famous-non famous judgements were made were in upper-case and presented in a bold blue font.

Each trial started with fixation for 1 second, the fixation point was replaced by the prime (i.e. the face or name in black font) for 200ms, followed by a blank screen for 200ms. Immediately afterwards the probe name appeared (in bold blue uppercase font) for 3 seconds or until the participant responded. Participants were instructed to pay attention to the prime, but their primary task was to classify the names as either famous or non-famous. Participants indicated their responses by pressing one of two buttons with either their right index ('famous') or middle finger ('non-famous').

Following the first priming session MA was administered a second famous faces test. In this test she was presented with 46 famous faces (one at a time), 21 of which were the same faces that were used in the priming experiment. She was given an unlimited amount of time to name each of the faces. Her responses were considered correct if she could name the person, or if she could provide accurate biographical information about them (e.g., naming a television show the person was on, and the character they played on that show). However, classification into a broad category (e.g., male actor) was not considered a correct identification. MA scored 52% correct on this famous faces test. Her accuracy was likely somewhat inflated compared to our previous famous faces test (35%; Table 1) due to the fact that she had been presented with the names of a limited set of famous names for over half an hour. This would have made guessing in this test somewhat easier.

Data analysis

First we calculated the average response time (RT) for correct trials in each condition. We then removed RTs that were less than 150ms or more than two standard deviations above the participants' overall mean (this accounted for less than 5% of trials). Data for controls and MA were analyzed separately using within-subject ANOVAs. To index priming we carried out a restricted number of planned comparisons using Fisher's protected t-tests. Specifically, for the face and name priming tasks we contrasted RTs for the semantically 'related' vs. the 'unrelated' condition, and the 'correct' name versus the 'unrelated' condition. For MA the same planned comparisons were carried out. Finally, to ensure that any priming effects that may be present in MA were not driven by overt recognition of the face primes, we removed data from all trials in the three critical conditions that contained faces primes which were overtly recognized during the famous faces test conducted after the initial priming session.

Results

Controls

In the face priming task the ANOVA analysis ($F(2,24)=77.18$, $p<.0001$) indicated that a significant difference between the 3 conditions. Planned comparisons indicated that controls were significantly faster to classify the name as famous if it was preceded by a related (740ms) compared to an unrelated face prime (767ms; $p=.001$). In addition, controls were faster to classify the name as famous if it was primed by the face that matched the name (650ms) compared to the unrelated condition (767ms; $p<.001$). We refer to this as the “true face effect”.

The pattern of results were similar for the name-name priming task ($F(2,24)=35.88$, $p<.001$). Controls were faster to classify a name as famous if it was preceded by a related name prime (583ms) than if it was preceded by an unrelated name (636 ms; $p<.001$). They were also faster to classify a name as famous if it was preceded by the same name in a different colour and font (509 ms) than an unrelated name 636 ms ($p<.001$).

MA

The results from the face priming task were collapsed across the 3 sessions as there was no significant interaction between condition and testing session ($F(4,66)=0.328$, $p=.86$). There was however, a main effect of condition ($F(2,66)=6.94$, $p<.002$), and because of the large number of trials, the observed power to detect differences between conditions was large (.91). Despite adequate power, MA’s RTs for the related condition (696ms) were not significantly faster than the RTs for the unrelated condition (708ms; $p=.59$) – that is she failed to demonstrate a significant face semantic priming effect. Importantly, RTs in the correct condition (589ms) *were* significantly faster than the unrelated condition (708ms; $p<.0001$). In short, MA failed to demonstrate a priming effect, but was able to demonstrate evidence for a “true face effect.”

Results for the name priming task were also collapsed across the 3 sessions given that there was no interaction between condition and session ($F(4,161)=1.67$, $p=.15$). There was a significant main effect of condition ($F(2,161)=16.26$, $p<.0001$). Planned comparisons revealed significantly faster RTs in the related condition (527ms) compared to the unrelated condition (571ms; $p<.001$). In addition, RTs in the correct name condition (457ms) were significantly faster than the unrelated condition (571ms; $p<.0001$). Thus MA demonstrated the same pattern of priming in the name priming task as controls.

In addition, a second approach was used to analyze MA's data. Instead of aggregating all of her data from the three sessions to ensure adequate power as above, we averaged the response times of identical trials in the three sessions, and entered these averages into an ANOVA. This analysis reduced the degrees of freedom to amounts comparable to those in the control group. Importantly this second approach yielded an identical pattern of findings as the aggregated approach. Specifically, in the face priming task ($F(2,25)=4.35$, $p=.026$) MA showed a significant true face effect ($p=.04$), but no face priming effect ($p=.47$; observed power =.69). In addition, in the name priming task ($F(2,59)=8.75$, $p<.0001$) MA continued to demonstrate significant correct name ($p=.001$) and priming effects ($p=.017$).

Discussion

In the current study we investigated face-name and name-name priming in MA, an individual with CP. For name-name priming MA demonstrated semantic and correct name priming effects that were similar to those shown by controls. Consistent with previous work (Barton, Cherkasova, & O'Connor, 2001; Barton et al., 2004; Bentin et al., 2007; De Haan & Campbell, 1991) we found that MA failed to demonstrate a significant face-name semantic priming effect. However, MA *did* demonstrate a "true face effect." That is, when the prime face correctly matched the probe name MA was much faster to classify the name as famous compared to when the prime and probe were unrelated. This effect proved to be significant even though we removed all trials in which she may have been able to overtly identify the face prime (see Methods). This finding stands in contrast to Barton et al., 2001 who showed that CP patients were unable to match a given famous name to a face (and not to a foil) in a two-alternative forced choice task. In addition, Barton et al. 2004 showed that an individual with CP failed to demonstrate a “true face effect” in a face-name priming task similar to the one used in the current study.

These results suggest that some individuals with CP, such as MA, may be able to acquire face recognition units (FRUs; Figure 1) to a limited degree. The quality of these FRUs could be sufficient to result in sub-threshold activation of PINs that would enable *identity* priming or what some others have referred to as “direct priming” (i.e., the “true face effect”) but would *not* be sufficient to allow sub-threshold activation of semantic information (i.e. SIU’s) associated with the prime face. The association between semantic information and faces in MA would be considered weak at best given that these links failed to develop prior to the onset of her prosopagnosia (unlike cases of AP). This would result in the absence of back-activation from SIU’s to PIN’s that were semantically associated with the prime face, and hence the absence of a face-name semantic priming effect in MA (Figure 1). In essence, the current results could be explained in terms of a combination of a problem in acquiring adequate face representations (i.e., a storage problem) and an inability of PINs to access semantic information (via back activation) associated with these inadequately stored face representations.

One important difference between previous studies examining covert face priming in CP, and MA tested in the current study, are differences between face and object processing abilities. Specifically, patient AB tested by DeHann and colleagues (De Haan & Campbell, 1991) who failed to demonstrate face priming effects was also impaired at making within-category judgements of other objects. However, MA’s deficit is specific to faces and does not extend to non-face objects. This implies that the presence or absence of face priming effects in individual cases of CP may be related to both the severity and variability of face and object processing abilities between patients.

In summary, the present study provides the first demonstration of covert identity priming from faces in CP. Importantly, these data suggest that some individuals with CP may be able to acquire face representations in a degraded form that can facilitate identity priming (i.e. the "true face effect") but not semantic priming.

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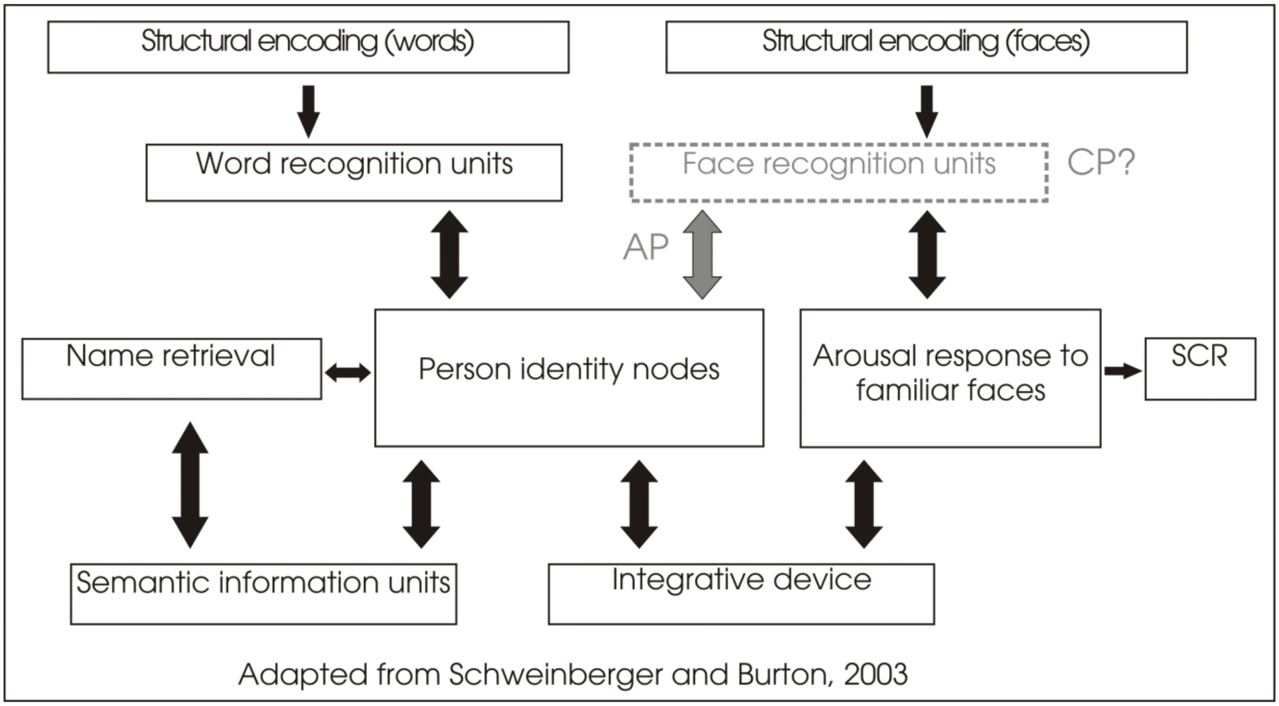
Figure captions:

Figure 1. Depicts the model of covert face recognition put forward by Schweinberger and Burton (2003). AP=Acquired prosopagnosia, CP=Congenital prosopagnosia, SCR=Skin conductance response.

Table 1: Results of the old/new discrimination tasks and the famous faces test for MA and controls (N=10). * indicates that MA is impaired relative to controls.

Test	**Controls (accuracy)**	**MA (accuracy)**
Unfamiliar faces	87% (SD=8)	50% (Z= -4.5)*
Cars	92% (SD=6)	100% (Z=1.4)
Guns	80% (SD=14)	83% (Z=0.2)
Houses	97% (SD=3)	100% (Z=1.3)
Tools	97% (SD=3)	95% (Z= -0.4)
Famous Faces	99% (SD=.02)	35% (Z= -30)*

Figure 1.


Structural encoding (words)
Structural encoding (faces)
Word recognition units
Face recognition units
CP?
AP
Name retrieval
Person identity nodes
Arousal response to familiar faces
SCR
Semantic information units
Integrative device
Adapted from Schweinberger and Burton, 2003