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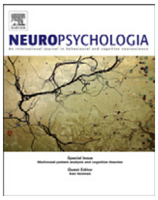

Motion as a cue to face recognition: Evidence from congenital prosopagnosia

Christopher A. Longmore [a,b,*], Jeremy J. Tree [c]

[a] School of Psychology, University of Exeter, Exeter, UK
[b] School of Psychology, University of Plymouth, Portland Square, Drake Circus, Plymouth, Devon PL4 8AA, UK
[c] Department of Psychology, University of Swansea, Swansea, UK

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ABSTRACT

Congenital prosopagnosia is a condition that, present from an early age, makes it difficult for an individual to recognise someone from his or her face. Typically, research into prosopagnosia has employed static images that do not contain the extra information we can obtain from moving faces and, as a result, very little is known about the role of facial motion for identity processing in prosopagnosia. Two experiments comparing the performance of four congenital prosopagnosics with that of age matched and younger controls on their ability to learn and recognise (Experiment 1) and match (Experiment 2) novel faces are reported. It was found that younger controls' recognition memory performance increased with dynamic presentation, however only one of the four prosopagnosics showed any improvement. Motion aided matching performance of age matched controls and all prosopagnosics. In addition, the face inversion effect, an effect that tends to be reduced in prosopagnosia, emerged when prosopagnosics matched moving faces. The results suggest that facial motion can be used as a cue to identity, but that this may be a complex and difficult cue to retain. As prosopagnosics performance improved with the dynamic presentation of faces it would appear that prosopagnosics can use motion as a cue to recognition, and the different patterns for the face inversion effect that occurred in the prosopagnosics for static and dynamic faces suggests that the mechanisms used for dynamic facial motion recognition are dissociable from static mechanisms.

1. Introduction

Studies investigating face processing have typically relied upon the use of static images of faces (Calder, 2011). In a typical face recognition study participants are shown a series of static facial images that they are then later asked to identify from a larger set of faces and such an investigation technique has revealed a wealth of information regarding face processing. For example, it has been shown that the recognition of familiar faces is very good (Bruce, 1982) even when the source image is of low quality, such as that obtained from CCTV footage (Burton, Wilson, Cowan, & Bruce, 1999). In contrast, the recognition of unfamiliar faces (i.e. faces seen only once or twice) is relatively poor, error prone, (Bruce, 1982; Bruce et al., 1999; Burton et al., 1999; Hancock, Bruce, & Burton, 2000; Krouse, 1981; Liu & Chaudhuri, 2000) and heavily tied to the originally studied image (Bruce et al., 1999; Longmore, Liu, & Young, 2008).

Despite the large difference exhibited between familiar and unfamiliar face processing, one effect persists regardless of the familiarity of the face. It has been consistently shown that presenting faces in an inverted orientation makes them harder to recognise (Bartlett & Searcy, 1993; Johnston, Hill, & Carman, 1992; Maurer, Le Grand, & Mondloch, 2002; Yin, 1969). The main reason why inversion affects face recognition so dramatically is thought to be through the disruption of either second-order configural cues, namely the spatial relationships between the features of a face (Bartlett & Searcy, 1993; Johnson, Dziurawiec, Ellis, & Morton, 1991; Maurer et al., 2002), or the holistic processing of faces, defined as the processing the face as a whole with spatial relationships and local features combined into a gestalt (McKone & Yovel, 2009). Our sensitivity to the effects of inversion in faces appears to be tied to a degree of "expertise" with the object in question as other stimuli tend to yield reduced inversion effects compared to faces (Yin, 1969) although the exact nature of such expertise is hotly debated. For example, some have argued that as people become experts in the visual processing of objects other than faces, these objects begin to take on some of the properties of faces and this expertise is evidenced by enhanced inversion effects relative to non-experts for their chosen category (e.g., dog experts; Diamond & Carey, 1986). Thus, under such an account, the face inversion effect is the result of the extensive experience we have with faces. However, incidents of increased inversion effects for objects of expertise are sporadically reported in

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[*] Corresponding author at: School of Psychology, University of Plymouth, Portland Square, Drake Circus, Plymouth, Devon PL4 8AA, UK.
Tel.: +44 1752 584890; fax: +44 1752 584808.
E-mail address: chris.longmore@plymouth.ac.uk (C.A. Longmore).

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the literature leading to the alternative view that faces are considered special stimuli and are processed by dedicated processes that are not used when processing other objects of expertise (see McKone & Robbins, 2011; Robbins & McKone, 2007 for a comprehensive review). Such a view proposes that the processes involved in face perception and recognition are not recruited for the processing of other objects of expertise and remain exclusively for the use of faces. The face inversion account according to this view is due to the face not being presented in the way it is typically encoded and processed by dedicated face processing systems (Haxby, Hoffman, & Gobbini, 2002).

Considering that faces are rarely, if ever, perceived in a static state in everyday life, the investigations into face learning need to take the role of motion into account. There are two ways in which motion may aid the recognition of faces: (1) the representation enhancement hypothesis (REH), which states that motion allows for greater refinement of the structural model of the face to be used for recognition (hence resulting in enhanced recognition) and (2) the supplemental information hypothesis (SIH), which proposes that characteristic motion is instead a separate cue to recognition—a cue that is stored independently from the structural information of the face (O'Toole, Roark, & Abdi, 2002). These two processes may not be mutually exclusive and instead complementary, and it has been suggested that the two types of cue may be used when different tasks are required. For example, representational enhancement might be particularly useful for the learning of new faces as the increased number of views of a face might refine the mental representation of a previously unfamiliar face by providing more views of the individual. Conversely, the recognition of already familiar faces might benefit from supplemental information of idiosyncratic facial motion that is typical of the individual (O'Toole, Roark, & Abdi, 2002).

In the case of recognising already familiar faces, presenting a high quality video clip of the face will confound the pictorial information present in the individual frames of the video (that in themselves are sufficient for recognition) with the characteristic motion patterns displayed in the film. To counter this, impoverished stimuli, created by degrading the image are used to remove pictorial information whilst leaving motion cues intact. Such an approach has revealed that motion can act as a cue for recognising familiar faces from threshold processed video (Lander, Christie, & Bruce, 1999), blurred and pixelated video clips (Lander, Bruce, & Hill, 2001) and limited frame sequences (Lander & Bruce, 2000).

Since unfamiliar face recognition has been shown to be poor, image degradation tends not to be required and instead, the recognition of faces learnt from a video sequence is compared to either static images or a limited number of frames from a video sequence (e.g. Bruce et al., 1999; Bruce & Valentine, 1988). Contrary to the results obtained from familiar face studies, recognition tasks using moving unfamiliar faces do not appear to suggest any benefit of motion over viewing a static image of a face. However, some matching tasks have revealed a motion advantage (see Roark, Barrett, Spence, Abdi, & O'Toole, 2003 for an overview).

1.1. Prosopagnosia

For the majority of people, the recognition of familiar faces is an effortless task. However, for a small percentage of the population (approximately 2–2.5%, Bowles et al., 2009; Kennerknecht et al., 2006), recognising even highly familiar faces (such as family members) is difficult and error prone. Prosopagnosia is an impairment that severely interferes with the ability to recognise familiar faces (Bodamer, 1947; Ellis & Florence, 1990). Prosopagnosics often rely on suboptimal strategies to recover identity information (e.g., hairstyle, clothing, gait or voice). Their performance on tasks involving inverted faces tends to be very similar to that obtained from upright faces and in some cases their performance is actually better with inverted faces (Boutsen & Humphreys, 2002; Marotta, McKeeff, & Behrmann, 2002; Schmalzl, Palermo, Harris, & Coltheart, 2009), an effect known as the *inverted inversion effect* (Farah, Wilson, Drain, & Tanaka, 1995). Given the suggestion that inversion effects in normal participants reflect the use of holistic information, the lack of an effect in prosopagnosics may indicate their inability to use holistic facial information (Boutsen & Humphreys, 2002; Farah, Wilson, Drain, & Tanaka, 1998; Levine & Calvanio, 1989; Moscovitch, Winocur, & Behrmann, 1997) and the impairment of specific face processing systems (Duchaine, 2006; Yovel & Duchaine, 2006).

As with experiments conducted with non-prosopagnosic individuals, studies investigating face processing in prosopagnosia have tended to employ static facial images. Of those that have examined the role of facial motion in prosopagnosia, studies from lip reading (Campbell, 1986, 1992; Dobel, Bolte, Aicher, & Schweinberger, 2007; Lange et al., 2009) and expression analysis from point light displays (Humphreys, Donnelly, & Riddoch, 1993) have been reported, as well as more general body motion from point light displays (Lange et al., 2009). These studies have revealed that prosopagnosic participants can display near normal, or normal levels of face processing compared to controls when the facial stimulus is presented in motion.

With respect to the learning of new faces from motion in prosopagnosia, Lander, Humphreys, and Bruce (2004) report the case of HJA, an individual with acquired prosopagnosia. HJA was impaired in his recognition of familiar faces from static images and, whilst his perception of global motion was intact, he was unable to use motion to aid his recognition of familiar faces nor in learning new faces, performing at a similar level regardless of whether the face was presented statically or dynamically. Interestingly though, he could use motion to aid his performance in *matching* unfamiliar faces. Thus, the results from HJA draw some parallels with those from non-prosopagnosic individuals—both were unable to use motion in recognition tasks but could use motion in matching tasks.

HJA suffered his brain injury after a stroke at 61 years of age and, like other acquired prosopagnosic cases (i.e. individuals who have developed prosopagnosia as the result of brain injury), his compensation strategies may have been sub-optimal due to the insufficient time he had to develop new strategies, increase expertise in existing ones (possibly including the cue of motion), or increase his sensitivity to motion cues to aid his face recognition. A second form of prosopagnosia, that has been present since early in life and termed developmental prosopagnosia (Duchaine, 2011) or congenital prosopagnosia (Behrmann & Avidan, 2005), may be more useful in determining whether motion can be extracted and used as a cue for recognition. This is because the individual has not "lost" any face processing ability (i.e. normal levels of face recognition have always been absent) and has been relying on other cues to identity and may have developed an enhanced sensitivity to characteristic motion of someone's face. It may be that if facial motion is processed independently to static cues, then a congenital prosopagnosic may be able to identify the characteristic facial motion of an individual, even if they have difficulty in processing the static pictorial information present in a face. Steede, Tree, and Hole (2007a, 2007b) investigated such a prosopagnosic, CS. Steede et al. presented CS with a generic computer generated model of a human face onto which a series of different characteristic motions were mapped during learning trials. During testing, they found that CS could identify those facial motions he had seen before and hence it appears that CS could use characteristic motion as a cue to facial identity, a result in contrast those obtained by Lander et al. (2004) from HJA.

The different patterns of performance seen across CS (a congenital prosopganosic) and HJA (an acquired prosopagnosic)