Why are moving faces easier to recognize?

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Previous work has suggested that seeing a famous face move aids the recognition of identity, especially when viewing conditions are degraded (Knight & Johnston, 1997; Lander, Christie, & Bruce, 1999). Experiment 1 investigated whether the beneficial effects of motion are related to a particular type of facial motion (expressing, talking, or rigid motion). Results showed a significant beneficial effect of both expressive and talking movements, but no advantage for rigid motion, compared with a single static image. Experiment 2 investigated whether the advantage for motion is uniform across identity. Participants rated moving famous faces for distinctiveness of motion. The famous faces (moving and static freeze frame) were then used as stimuli in a recognition task. The advantage for face motion was significant only when the motion displayed was distinctive. Results suggest that reason why moving faces are easier to recognize is because some familiar faces have characteristic motion patterns, which act as an additional cue to identity.

One of the first experiments to directly address the role of movement in face recognition was carried out by Knight and Johnston (1997), who showed that negated images of famous faces were better recognized when they were displayed moving, compared with a single static image. As familiar face recognition is typically so good (see Burton, Wilson, Cowan, & Bruce, 1999), it is usually necessary to degrade spatial cues in order to investigate the importance of dynamic information for face recognition. In later work, the advantage of motion was shown to extend to the recognition of famous faces degraded by inversion, pixelation, thresholding (reducing the image to a black-on-white display), and gaussian blurring (see Lander, Bruce, & Hill, 2001; Lander, Christie, & Bruce, 1999). It seems clear that, under these nonoptimum viewing conditions, motion has the ability to add information useful for recognition.

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Of course the fact that motion aids recognition may not be due to a genuine ''dynamic'' effect. Recognition may be better because of the increased number of static pictures contained in a moving sequence. However, when the same frames were displayed either as static array or an animated sequence, recognition was still significantly higher from the moving sequence (see Lander et al., 1999). Furthermore, the precise dynamic characteristics of the observed motion seemed to be important in mediating the recognition advantage of motion. Recognition of degraded famous faces was best when the observed motion retained its original dynamic characteristics, compared with slowed down, speeded up, reversed, or rhythm disrupted motion (Lander & Bruce, 2000; Lander et al., 1999). So, seeing a famous face moving naturally aids the recognition of identity. There are several theoretical interpretations for this suggestion.

First, there may be some generalized benefit for viewing a face moving naturally. O'Toole, Roark, and Abdi (2002) refer to the ''representation enhancement hypothesis'', positing that facial motion contributes to recognition by facilitating the perception of the 3-D structure from the face. However, mathematical analysis of this ''structure-from-motion'' process typically assumes rigid motion (Ullman, 1979), an assumption violated by the nonrigid facial movements predominantly displayed by famous face stimuli (see Knight & Johnston, 1997; Lander et al., 1999, 2001). However, more recent work addresses the problem of structure from nonrigid motion (e.g., Black & Yacoob, 1997; Pentland & Horowitz, 1991). It seems at least possible that there are clues to the structure of the face from nonrigid as well as rigid motion. Interestingly, the visual system may be particularly tuned in some way to deal with faces moving naturally, rather than those moving ''unnaturally'' (for example, in reverse or speeded up) or not at all (see Johannson, 1973; Stevenage, Nixon, & Vince, 1999 for accounts of biological motion). Indeed, it may not be too surprising that altering these parameters degrades recognition performance when we consider that all alterations change the observed pattern over time. However, what is interesting is the extent to which the visual system is sensitive to such changes, and the apparent ability it has to utilize this information.

A second interpretation of the recognition advantage for moving faces, initially suggested by Knight and Johnston (1997), is that each known face has an associated ''characteristic motion signature'' that acts as an additional cue to identity (termed ''supplemental information hypothesis'' by O'Toole et al., 2002). If this were the case then the identity of the face must be originally learnt in motion, with the ''characteristic'' information extracted for very familiar faces, over a period of time.

While these suggestions are useful, more information is needed about the exact nature of the motion recognition advantage, for practical and theoretical purposes. For example, does motion always aid familiar face recognition? Will any kind of motion stimulate these recognition advantages? Do the effects of motion depend on the identity of the viewed face? We address these questions in this article. By doing so we hope to gain a clear idea of when motion aids recognition. Investigation of this issue should also help inform us why motion is beneficial for recognition.

In our first experiment we investigate which aspects of facial motion are important in mediating the recognition advantage for moving familiar faces. Previous work in this area (see Knight & Johnston, 1997; Lander & Bruce, 2000; Lander et al., 1999) has used moving sequences of famous faces that display a mixture of different types of nonrigid motion (expressing, talking), as well as some limited rigid motion (head nodding and shaking). No study, to our knowledge, has systematically explored whether the beneficial effects of motion on the recognition of familiar faces are limited to a specific type of motion. If, for example, seeing a face talking, but not expressing, aids successful recognition, then this strongly suggests visual speech movements are particularly important in mediating the moving recognition advantage. Similarly, if recognition advantages are due to rigid head movements, facilitating the perception of 3-D shape (Ullman, 1979), then beneficial effects should only be shown with rigidly moving faces, not those moving nonrigidly. In Experiment 1 we compare the recognition of personally familiar faces that are moving rigidly (head nodding), expressing (smile; nonrigid), speaking (nonrigid) and viewed as a single static image. Personally familiar faces were used in this experiment, rather than famous faces, allowing the type of motion displayed to be controlled. Faces used were psychology teaching and lecturing staff at the University of Manchester, and participants were students in the psychology department.

In addition to the type of motion, in Experiment 1 we also explore the relationship between the level of face familiarity and the effect of motion. Previous studies simply verified (after testing) whether each participant ‘‘knew’’ (yes/no) the famous person used in the experiment. It may be that movement of the face is only helpful when we are highly familiar with the observed face, and/or that its beneficial effect becomes more pronounced as we become increasingly familiar with the way it moves. Indeed, Knappmeyer, Thornton, and Bülthoff (2003) comment that ‘‘familiarity seems to be one factor that has a strong impact on the detection of motion effects’’ (p. 1933). Accordingly, in our experiment we ask participants, after the experiment, to rate each known face for familiarity. Using these ratings we determine the relative advantage of motion across different levels of face familiarity.

EXPERIMENT 1

Method

Participants. Forty-eight participants (10 men and 38 women), all between 19 and 26 years old (mean 21 years), participated voluntarily in experiment. All were second- and third-year psychology students from the University of

Manchester, likely to be familiar with some of the lecturers and teaching staff shown in the experiment. All participants had normal or corrected-to-normal vision.

Materials and design. The experiment had a one between-participants factor of Presentation (rigid, expressing, talking, static). Allocation of participants to conditions was made in a random fashion, with 12 participants in each condition. The order in which the clips were displayed was randomized for each participant. The rigidly moving clips showed the face looking up then down, returning to the full-frontal position, maintaining a neutral expression throughout. The expressing clip showed the face smiling, typically starting from a neutral expression and moving to a smile (natural smiles captured during filming, rather than posed smiles). The speaking clip showed the face talking, reciting letters of the alphabet. The static clip comprised of a single frame of a full-frontal face, extracted from footage not shown in any of the other presentations. It was typical of the face in that it avoided any unusual momentary expressions, as well as any unusual head movement or angle. All clips were 1.5 s in length (25 frames per s).

All experimental stimuli were derived from a set of moving video images, comprising of 32 faces of people who could have been personally familiar to our participants. This set was created under controlled lighting conditions using a digital camcorder (model: Sony DCRTRV80). All filmed individuals were from the University of Manchester and were either teaching/research/administrative staff and postgraduate students of the Department of Psychology (30), or external staff (2). All clips displayed the head and shoulders of the person from a frontal viewpoint. Filmed individuals maintained a fixed distance of approximately 1.1 m from the camcorder, in front of a green background. Lighting came from two indirect sources. The main light source was provided by two spotlights (1000 W) that reflected light off a vertical reflector panel (dimensions: 125 high $\times$ 184 wide) placed behind the camcorder, and onto the filmed individual. The secondary light source was provided by a 40 W floor-light covered by a diffuser, placed under the camcorder.

All the images were subsequently captured onto a computer using Adobe Premiere (v. 6.3) that was also used to transform the raw footage into a slightly degraded format. From the footage of each filmed person, four clips of 1.5 s were extracted, each depicting one of the presentation conditions. Each clip was transformed by a sequence of filters, applied in the following order: Black–white, contrast (-60), brightness (+60), camera blur (+60). In addition, each face was clipped with black borders so as to reveal only the face and remove nonfacial features, e.g., hairstyle, from presentation. The image size of each familiar face was equivalent across the four conditions of presentation, and varied slightly across individuals according to face shape. The final product was a Quicktime movie file (Cinepak video-compression). Image degradation was

Figure 1. Examples of the static images used for recognition in Experiments 1 (degraded image of academic member of Psychology department, shown on left) and 2 (thresholded image of Joan Collins, shown on right). Not shown to scale.

carried out to reduce the correct recognition of these familiar faces away from ceiling levels (see Davies, Ellis, & Shepherd, 1978). See Figure 1 for an example of a static image used. Experimental clips were displayed using a G4 Powermac, using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993).

Procedure. Participants, who were tested individually, were seated approximately 57 cm away from the computer monitor, which was positioned at eye-level on a table. They were informed that some of the faces shown belonged to people they would know, and were asked to try to name or provide some unambiguous semantic information about the person displayed whenever they recognized a viewed face. For example, specific names of courses taught were deemed correct, but general information such as ''lecturer'' without the provision of unique information was deemed not sufficient for a correct response. During the test sequences, the participant responded verbally, and these responses were recorded by the experimenter. No feedback was given. A potential problem with this kind of experiment is that the ''familiar'' faces used in the experiment may not be familiar to all the participants involved in the experiment. Indeed, in our experiment it was likely that participants would not be familiar with all the faces shown, as not all students take all courses. To compensate for this issue, at the end of the experiment, participants were presented with an array of undegraded still images of all of the faces used in the experiment (utilizing the original good quality images captured from video). Participants were asked to indicate the faces with which they were familiar. The results of each participant were scored, as a proportion of the faces known to them (recognition rate). For example, if a participant was familiar with only 20 of the faces, and they recognized all of these 20 correctly, they were given a score of 100%. Participants were also asked to reconfirm their experimental responses by matching their familiar faces with their verbatim responses. All participants were familiar with at least 12 faces, with a mean of 18 familiar faces (SD = 4.3) included in the experiment. The remaining faces, not familiar to the participant, acted as distracters.

Finally, participants were asked to rate faces they were familiar with on a scale of 1 to 7 for familiarity (1 = not very familiar; 7 = very familiar). We conducted a median split whereby, for each participant, scores were divided into a ''more'' familiar and ''less'' familiar group (mean ''less'' familiar rating = 3.2, SD = 1.8; mean ''more'' familiar rating = 6.1, SD =1.4). Familiarity level was added as an additional factor in the statistical analysis (within-participants factor).

Results

Accuracy was analysed in two ways. Firstly the percentage of target faces correctly recognized in the test phase (recognition rate) was calculated (as a proportion of known faces). Secondly, the recognition rate was combined with the percentage of distracter faces incorrectly recognized (false alarms; FA), using the nonparametric signal detection measurements of A' and B''. This analysis was undertaken to determine whether observed effects arose from shifts in sensitivity to some of the variables (see Snodgrass & Corwin, 1988). See Table 1 for results. Given that distractor faces could not be classified as more or less familiar, it was only possible to assign a mean FA rate to each presentation condition. This meant that any difference between the A' and B'' for the level of familiarity factor, could only be due to a change in the recognition rate, and not, as usual, be due to the addition of the FA rate. This procedure, although not ideal, is more sensitive than an analysis of the recognition rates alone, as it includes some indication of the accept/reject criterion adopted by individual participants. See Table 1 for results.

A 4 (presentation) $\times$ 2 (familiarity) mixed analysis of variance of the recognition rate and A' revealed a significant main effect of presentation: Recognition rate by participants, $F(3, 44) = 9.0$, $p < .001$; recognition rate by items, $F(3, 90) = 8.4$, $p < .001$; A' by participants, $F(3, 44) = 4.6$, $p < .005$. Further analysis of the differences, using post hoc Newman Keuls pairwise comparisons revealed a significant difference between the static condition and both the expressing and talking conditions. There was no significant difference between the static and the rigid conditions, and no significant difference between the talking and expressing conditions. Finally, the difference between the rigid and expressing conditions reached significance, but the difference between rigid and talking just failed to reach significance (p = .055).

There was also a significant effect of familiarity: Recognition rate by participants, $F(1, 44) = 73.7$, $p < .001$; recognition rate by items, $F(1, 30) =$

TABLE 1
Mean recognition rates (%), false alarms (FA, %), A' and B'' with standard deviations (*SD*, in brackets) in each of the conditions of Experiments 1 and 2

	Presentation condition			
Experiment 1	*Rigid*	*Expressing*	*Talking*	*Static*
More familiar				
Recognition rate	69.9 (14.5)	89.5 (6.8)	82.4 (11.7)	56.5 (22.0)
A'	0.84 (0.11)	0.93 (0.06)	0.93 (0.05)	0.82 (0.08)
B'	0.35 (0.43)	0.25 (0.47)	0.27 (0.48)	0.47 (0.35)
Less familiar				
Recognition rate	39.4 (15.1)	55.5 (18.7)	58.0 (29.3)	36.3 (17.3)
A'	0.73 (0.13)	0.81 (0.10)	0.83 (0.13)	0.72 (0.09)
B''	0.43 (0.36)	0.47 (0.48)	0.48 (0.48)	0.36 (0.33)
Mean FA rate	14.7 (12.8)	13.6 (15.2)	8.8 (9.1)	14.2 (14.0)
Experiment 2	*Distinctive moving*	*Distinctive static*	*Typical moving*	*Typical static*
Recognition rate	77.3 (12.2)	63.0 (14.9)	67.8 (12.6)	63.9 (16.1)
FA	10.9 (7.1)	13.0 (8.2)	12.3 (5.7)	14.9 (10.6)
A'	0.89 (0.06)	0.83 (0.07)	0.86 (0.05)	0.83 (0.08)

163.8, $p < .001$; A' by participants, $F(1, 44) = 50.2$, $p < .001$, whereby the faces rated as more familiar were better recognized, than those rated as less familiar. The interaction between presentation and familiarity was not significant: Recognition rate by participants, $F(3, 44) = 0.9$, $p > .05$; recognition rate by items, $F(3, 90) = 0.4$, $p > .05$; A' by participants, $F(3, 44) = 0.2$, $p > .05$.

FA rates are shown in Table 1. Analysis of the FA data showed no significant effect of presentation: Recognition rate by participants, $F(3, 44) = 0.6$, $p > .05$; recognition rate by items, $F(3, 90) = 0.2$, $p > .05$.

Analysis of the B'' data showed no significant effect of presentation, $F(3, 44) = 0.4$, $p > .05$, no significant effect of familiarity, $F(1, 44) = 3.5$, $p > .05$, and no interaction between familiarity and presentation, $F(3, 44) = 2.0$, $p > .05$.

Discussion

We have replicated and extended previous findings, by showing a beneficial effect of expressing and talking motion when recognizing personally familiar faces. Thus it seems clear that the advantages shown in previous experiments (Knight & Johnston, 1997; Lander et al., 1999, 2001) are linked to nonrigid motion, and shown with either expressing or talking movements. Interestingly, there was no overall significant beneficial effect for seeing a face moving rigidly, compared with viewing a single static image. However the rigid head movements used here were very limited and posed—looking up or down. Previous research (Bruce & Valentine, 1988) using similar movement also failed to find a significant advantage for rigid motion. Conversely, advantages of rigid movement (see Lander & Bruce, 2003; Pike, Kemp, Towell, & Phillips, 1997; Schiff, Banka, & de Bordes Galdi, 1986) have been shown when learning previously unfamiliar faces. There is also some evidence that naturally occurring (as opposed to posed) rigid movements may also serve as characteristic signatures, providing information useful for recognition independent of any contribution to structure-from-motion (Hill & Johnston, 2001).

In terms of familiarity, as expected more familiar faces were better recognized than less familiar faces (Burton et al., 1999). Beneficial effects of motion were shown with both ‘‘more’’ and ‘‘less’’ familiar faces, with no significant difference between the size of the recognition advantage.

So, we have established that nonrigid motion is important for generating motion advantages for recognition, but the question still remains about whether this reflects characteristic motion signatures of individual identities, or a more general benefit for seeing faces move. One way to explore this issue is to investigate whether the beneficial effect of motion is uniform for all face identities. We investigate this issue in Experiment 2. If familiar faces have ‘‘characteristic motion patterns’’, then particular features of a person’s facial movement must be linked to their stored face representation. Consequently the distinctiveness of the observed motions may be important, with the beneficial effect becoming more pronounced as the face moves in a more ‘‘characteristic’’ or distinctive manner (see Giese, Knappmeyer, & Bülthoff, 2002). Some support for this suggestion comes from work by Hill and Pollick (2000) who showed that exaggerating the dynamic properties of a simplistic point-light display facilitated the recognition of individuals (also see Pollick, Hill, Calder, & Patterson, 2003 for work on expression recognition and exaggeration). In this study participants first learned to recognize six individuals from point-light displays of simplistic arm movements. Subsequently they were shown exaggerated versions of these movements and asked to try to discriminate among the learned people. Results showed that recognition performance increased with level of exaggeration (levels of exaggeration tested from −50% to +100%; see Hill & Pollick, 2000 for further details). Absolute duration did not appear to be the critical cue. Rather, Hill and Pollick suggest that time-based cues were used for the recognition of movements, and consequently, exaggerating such cues improved recognition performance.

In Experiment 2, participants completed a standard recognition experiment, with faces shown both moving and static. The moving clips were previously rated for distinctiveness, on a scale of 1 (very typical motion) to 7 (very distinctive motion). On the basis of these ratings the famous faces were allocated to two groups—distinctive and typical motion. If the characteristics or distinctiveness of the observed motion is important, then there should be a greater beneficial effect of motion for faces that move in a distinctive manner compared with those that move more typically. Of course, ratings of motion distinctiveness should have little effect on the recognition of static faces.

EXPERIMENT 2

Method

Rating of motion distinctiveness. Thirty volunteers (5 men and 25 women), all between 20 and 23 years old (mean 21 years), voluntarily rated the moving clips for distinctiveness. Raters viewed 80 greyscale clips (nondegraded) of famous faces, previously collected for recognition experiments of this kind (see Lander & Bruce, 2000; Lander et al., 1999, 2001). The moving clips comprised the original moving sequence, as captured from TV or video. All experimental clips displayed at least the head and shoulders of the person from a frontal viewpoint. The motion was mainly of a nonrigid nature (expressions and speech) with some additional rigid motion (head nodding and turning).

For each face, raters were asked to give the motion shown a rating of distinctiveness, on a scale of 1 (very typical) to 7 (very distinctive). Each clip was 2.5 s in length and they were given as long as they needed to write down their response, before the next clip was displayed. Raters were asked to ignore whether the face was familiar to them or not, and were asked to simply concentrate on the motion shown. The order of presentation of the clips was randomized. Across raters the average rating of distinctiveness, for each famous face, was calculated. The top 40 faces were assigned to the ‘‘distinctive’’ motion group (average rating = 5.2, $SD = 1.2$). The bottom 40 faces were assigned to the ‘‘typical’’ group (average rating = 2.4, $SD = 1.5$). The degree of interrater reliability between participants for the distinctiveness ratings was calculated using Cronbach’s alpha ($\alpha = .73$).

Participants. Forty-eight participants (18 male and 30 female), all between 18 and 24 years old (mean 20 years) took part in the recognition experiment. All participants were students from the University of Manchester who had not rated the clips for distinctiveness or participated in any other experiments of this kind. All had normal or corrected-to-normal vision.

Materials and design. In total 100 faces were used: 80 famous faces (previously rated for motion distinctiveness) and a further 20 unknown faces. The experiment had one within-participants factor of presentation (moving and static).

In the recognition experiment, all clips were thresholded to reduce the recognizability of the famous faces (see Figure 1) and move performance away from ceiling levels. The static clips comprised of a single freeze-frame (shown for 2.5 s) selected from the moving sequence. It was typical of the moving sequence in that it avoided any unusual momentary expressions, as well as unusual head movement or angle.

The test sequences were displayed to the participants using a 30 cm $\times$ 21 cm Sony Trinitron TV monitor, and the videotapes were played on a Sony VHS video recorder.

Procedure. Participants were informed that some of the faces belonged to famous people, and if familiar with the viewed face, were asked to try and name or provide some unambiguous semantic information about the person viewed. Names of roles played (e.g., ''Louise from the movie Thelma and Louise'' for Susan Sarandon) were deemed correct, as were unambiguous descriptions of the person (e.g., ''Prime Minister'' for Tony Blair). General information such as ''actor'' or ''comedian'' in the absence of any further information was deemed not sufficient for a correct response. Each test sequences was displayed using different videotapes, with the order counterbalanced, so that half the participants viewed the moving condition first and the other half the static first. Order of presentation within a test sequence was randomized. Before each test sequence, each participant saw two practice faces to familiarize them with the type of sequence they were going to see and the task requirements. At the end of the experiment, participants presented with an array of undegraded still images of all of the faces used in the experiment (utilizing the original good quality images captured from video). Participants were asked to indicate the faces with which they were familiar.

Results

See Table 1 for results. As in Experiment 1 the results of each participant were scored, as a proportion of the faces known to them (recognition rate). A 2 (presentation) $\times$ 2 (distinctiveness) analysis of variance of the recognition rate and A' data revealed a significant interaction between presentation and distinctiveness: Recognition rate by participant, $F(1, 47) = 15.8$, $p < .001$; recognition rate by item, $F(1, 78) = 4.2$, $p < .05$; A' by participant, $F(1, 47) = 5.0$, $p < .05$. Further analysis of the simple main effects revealed a significant beneficial effect of distinctive motion, $F(1, 47) = 58.8$, $p < .001$, but no significant advantage for typical motion, $F(1, 47) = 1.8$, $p > .05$, compared with a single static image.

There was also a significant main effect of presentation: Rrecognition rate by participant, $F(1, 47) = 28.2$, $p < .001$; recognition rate by items, $F(1, 78) = 9.1$, $p < .005$; A' by participant, $F(1, 47) = 13.7$, $p < .005$. As in previously reported experiments (see Lander & Bruce, 2001; Lander et al., 1999, 2000) correct recognition was significantly higher for moving faces than static ones. In addition there was a significant main effect of distinctiveness: Recognition rate by participant, $F(1, 47) = 8.5$, $p < .001$; recognition rate by item, $F(1, 78) = 4.4$, $p < .05$; A' by participant, $F(1, 47) = 4.1$, $p < .05$.

Discussion

As in previous recognition experiments, recognition of famous faces was significantly better from moving clips than static ones. Interestingly, in Experiment 2, the advantage for motion was only significant when the motion displayed was distinctive. This finding supports the idea that familiar faces have ''characteristic motion patterns'', whereby particular features of a person's facial movement are linked to their stored face representation. Accordingly, as the face moves in a distinctive manner, so the advantage for motion becomes more pronounced. As would be expected, ratings of motion distinctiveness had no effect on the recognition of static faces. Thus, we can exclude the possibility that participants were rating the distinctiveness of the face, rather than the motion (see Valentine, 1991).

One alternative interpretation of our results is that the rated distinctiveness of the observed motion simply reflected the amount of motion shown in a particular clip. If this were the case then as the amount of observed motion increased, so we would expect the advantage for motion to also increase. To rule out this possibility we asked a further set of raters (40 raters) to judge the amount of motion displayed in the moving clips, on a scale of 1 (very little motion) to 7 (lots of motion). There was no correlation between the distinctiveness of the observed motion and the amount of rated motion ($r = -.032$, $p > .05$). Hence, it seems that our rated distinctiveness is not a simple reflection of the amount of motion observed.

GENERAL DISCUSSION

First, we have confirmed that beneficial effects of face motion for recognition are not specific to a particular type of motion. Indeed in clips used previously (see Lander & Bruce, 2000; Lander et al., 1999, 2001) the motion displayed was an unspecified mix of nonrigid (talking, expressing) motion, with some limited rigid motion. In Experiment 1 we confirmed that similar beneficial effects are shown with faces displaying either just expressing (smiling) or talking movements. In contrast we showed no overall beneficial effect for viewing a face moving rigidly compared with viewing a single static image. Thus, it is not the case that seeing a face move always aids familiar face recognition Consequently, we suggest that nonrigid motion is more important factor in determining the moving face recognition advantage. Although faces rated as more familiar were better recognized, there was no difference in the size of the moving advantage for both more and less familiar faces. This may reflect the fact that in order for a face to judged as being ''correctly recognized'', participants needed to provide some identity specific information about the person viewed. Thus, although faces in the experiment were more or less familiar to individual participants, all were relatively well known. Further experiments could explore the effect of motion on recognition decisions for less familiar faces.

Second, we showed that the size of the recognition advantage for moving face is related to the distinctiveness of the observed motion. Thus, in answer to our question, will any kind of motion stimulate recognition advantages, we see that although seeing a face move aided the recognition of both typical and distinctive motion clips, the size of the advantage was much larger (and significant) for distinctive motion clips. We speculate that this may reflect the fact that as the face moves in a more ''characteristic'' or distinctive manner, so the usefulness of the motion cue is increased. Here, there are at least three possible senses in which the term ''distinctive'' could be used. First, distinctive may imply motion that is very characteristic or typical of a particular individual. However, in Experiment 2, raters were specifically asked to ignore whether the face was familiar to them, and simply concentrate on the motion shown. Second, distinctive may imply an odd motion for a person to do. Finally, distinctiveness may result from a generally odd, or unusual movement. Whatever the interpretation of motion distinctiveness, for people who move in a distinctive manner, motion may be a highly salient cue for recognition. Conversely for other people who move in a much more typical manner, motion may be a less helpful cue for recognition. Here it may be useful to draw on the large literature concerning face distinctiveness (see Valentine, 1991, 2001; Vokey & Read, 1992; Wickham & Morris, 2003). According to Valentine's face–space account, the effects of spatial distinctiveness can be interpreted by thinking of faces as located in face–space. The centre of the space is considered to represent the typical value in the population for each dimension. The nature and number of dimensions is a current topic for debate (for example, see Townsend, Soloman, & Spencer Smith, 1999), but the space is assumed to be multidimensional. Typical faces are more difficult to recognize as they cluster together in the centre of the space, and thus lie in regions where there is a high density of other similar faces. Conversely, distinctive faces are located at the edge of the space, making them further from neighbouring faces and so less susceptible to confusion with other faces. Just as we can make faces more distinctive, by spatially caricaturing them away from the norm, so we can temporally caricature image sequences. Work with arm movements and smiles shows that temporally caricaturing sequences makes the identity of these actions more recognizable (see Hill & Pollick, 2000; Pollick et al., 2003). Further work is needed to investigate the impact of temporal caricaturing on the recognizability of face identity, and the consistency of distinctiveness ratings for individual identities. It is important to determine whether the effect of motion is dependent on the identity of the viewed face or the nature of the clip viewed. It may also be possible to construct an objective measure of motion distinctiveness, using optic flow or face tracking techniques (see

DeCarlo & Metaxas, 2000). Ratings and objective measures may differ in interesting ways.

Finally we speculate on how we might test the notion of characteristic motion patterns. One simple possibility is to investigate if moving faces are easier to recognize when they have been learnt from static images. In this situation, characteristic motion information cannot have been extracted and associated with a face identity (as not provided). Consequently, no beneficial effects of motion for recognizing this face should occur. Similarly we could artificially animate faces that are well known, but have never been seen (at least by the present generation) in motion. Indeed, while most people know the identity of ''Abraham Lincoln'' or ''Queen Victoria'' from portraits or photographs, they have never seen them move. Again, specific characteristic motion information cannot have been associated with identity in this case. If the beneficial effects of motions are due to characteristic motion signatures, then there should be little beneficial effect of motion in the recognition of these historical figures. Work along these lines should provide a method of testing critically the idea of characteristic motion patterns.

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No.	*Page*	*Query*	*Answer*
Q1	13	Please provide town/city and state/country of publication. Bruce, V., & Valentine, T. (1988). When a nod's as good as a wink. The role of dynamic information in facial recognition. In M. M. Gruneberg & E. Morris (Eds.), *Practical aspects of memory: Current research and issues*. Lawrence Erlbaum Associates.	
Q2	13	Please provide town/city and state/country of publication, plus full name of publisher. Giese, M. A., Knappmeyer, B., & Bülthoff, H. H. (2002). Automatic synthesis of sequences of human movements by linear combination of learned example patterns. In H. H. Bülthoff, S. W. Lee, T. Poggio, & C. Wallraven (Eds.), *Biologically motivated computer vision 2002* (pp. 538–547).	
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Q4	8 14	Please confirm correct spelling. Schiff, W., Banka, L., & de Bordes-Galdi [OR de Bordes Galdi?], G. (1986). Recognizing people seen in events via dynamic ''mug shots''. *American Journal of Psychology*, *99*, 219–231.	
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Q6	11 12 12 14 14	Please confirm the correct year – these appear to be from the same publication. Townsend, J. T., Soloman, B., & Smith, J. S. (1999). The perfect Gestalt: Infinite dimensional Riemannian face spaces and other aspects of face perception. In M. J. Wenger & J. T. Townsend (Eds.), *Computational, geometric, and process perspectives on facial cognition: Contexts and challenges* (pp. 39–82). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.	

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