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Something in the way they move: characteristics of identity present in faces, voices, body movements, and actions

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The recognition of familiar individuals relies not only on static features of the person but also on dynamic characteristics unique to each person's movements. This mini review synthesizes current research on the role of motion in identity recognition, examining how characteristic dynamic cues from the face, voice, and body may contribute to perceivers' ability to recognize familiar individuals. We highlight corresponding dynamic covariances that may be present across different aspects of an individual's motion, such as those linking facial and vocal motion. We evaluate the extent to which dynamic patterns might form a coherent 'dynamic fingerprint.' Finally, we consider how variability, distinctiveness, and perceiver-related factors (e.g., individual differences and neural mechanisms) shape the recognition of identity through motion. We outline open questions and propose new directions for understanding the integration of dynamic information in person perception.

KEYWORDS

person identification, biological motion, dynamic characteristics, face, voice, gait, body movements

1 Introduction

The way a person moves reflects their underlying anatomy and changes in the positions of their bones and muscles (Mileva and Burton, 2018; Vick et al., 2007). Yovel and O'Toole (2016) argue that 'motion acts as the key element for binding together faces, bodies, and voices into a coherent representation of a person that supports recognition' (p. 383). Indeed, seeing a person move may provide a general 'form-from-motion' advantage for recognition, by providing additional views of the person, as well as enhanced structural information about the viewed individual (Johansson, 1973). A complementary idea is that for familiar people, the idiosyncrasies of their observed motion contribute to identity recognition. For example, individuals may have a characteristic smile or way of shaking their head, that serves as a cue to identity. This may also be true of idiosyncrasies present in other aspects of their biological motion, for example gait or gestures (Loula et al., 2005).

2 Dynamic characteristics of identity from face and voice

Faces move in rigid and non-rigid ways (Lander et al., 1999). During rigid motion, the face moves as a single object, for example during head nodding and shaking. In contrast,

non-rigid motion is deformable or elastic (Xiao et al., 2013), with parts of the face moving in relation to one another, for example when expressing, talking etc. Individuals vary in the amount and way they move their faces, and this can influence how they are perceived by others. Indeed, more facially expressive participants are rated as being more likeable, agreeable, and successful (Cavanagh et al., 2024). Conversely, people who do not move their faces very much are often perceived as uninterested. For example, see work on the impact of reduced facial expression in Parkinson's (Tickle-Degnen et al., 2011).

Research has shown that seeing a face move leads to better face matching (speaking, Bennetts et al., 2013; expressions, Thornton and Kourtzi, 2002), learning of unfamiliar faces (speaking, Butcher et al., 2011; non-rigid and rigid, Lander and Bruce, 2003; rigid, Pike et al., 1997) and identification of familiar faces (speaking, Butcher and Lander, 2017; non-rigid, Lander et al., 2001). The 'movement advantage' may be particularly pronounced when viewing conditions are difficult (Lander et al., 2001) or there is reduced recognition by the observer due to impairment (Bennetts et al., 2015; Longmore and Tree, 2013) or age (Otsuka et al., 2009; Xiao et al., 2014). Dynamic cues may be used flexibly when static cues are insufficient for identification, with facial form and motion information optimally integrated to support recognition (Dobs et al., 2017).

Seminal work by O'Toole et al. (2002) formalizes, for faces, the distinction between a general advantage of motion and one linked to the characteristics of the observed motion. Indeed, the 'representation enhancement hypothesis' (O'Toole et al., 2002; O'Toole and Roark, 2011) suggests that seeing a face move aids recognition by facilitating perception of the three-dimensional face structure. Here, there is thought to be a generic benefit (over any advantage of multiple statics) of seeing a face move, that is useful both when learning a face or when recognizing it (Pike et al., 1997; Butcher et al., 2011). The 'supplemental information hypothesis' (O'Toole et al., 2002) proposes that we represent characteristic facial motions of individual faces, in addition to the invariant structure of the face. These characteristic facial motions are referred to as 'dynamic identity signatures' (Simhi and Yovel, 2020) and are typically found through characteristic expressions, manner of speaking (Dobs et al., 2016) or ways of looking (Peterson et al., 2025). This theory is supported by studies that manipulate the temporal characteristics of the observed facial motion by slowing, speeding or reversing clips (e.g., Lander and Bruce, 2000; Lander et al., 2006). These manipulations disrupt the characteristic patterns of movement and reduce the movement advantage for familiar faces. Such characteristic information may be inherent to 'dynamic' representations (Freyd, 1987) or be stored alongside a static-based representation.

Importantly, dynamic facial signatures are thought to be learnt over time, providing a reliable cue to identity for familiar faces, and one that is increasingly useful the more familiar the face is. Accordingly, Butcher and Lander (2017) found that the magnitude of the motion advantage observed for an individual face correlated with how familiar that face was (but see Bennetts et al., 2013). Further, more distinctive facial movement patterns were associated with a greater movement advantage in familiar faces (Lander and Chuang, 2005). Here, distinctive refers to movement characteristics that differ from average or typical movements – they are unique, unusual, or idiosyncratic to an individual. This finding supports the idea that dynamic facial signatures are more relevant for familiar than unfamiliar face recognition.

Interestingly, dynamic characteristics in the way a face moves may also be present in the way a person sounds (Kamachi et al., 2003; Lander et al., 2007; Munhall and Buchan, 2004). Kamachi et al. (2003) found that participants could match unfamiliar faces to voices (or voices to faces) above chance and that matching performance was best with dynamic face stimuli (but see Lavan et al., 2021, who found chance-level dynamic face-voice matching). Face to voice matching tasks demonstrate that dynamic covariances of identity are present in the movement of faces and voices. Similar to visual-only dynamic identity signatures, these identity covariances are likely based on relative timing information: reversing or transforming speech in a non-linear manner disrupts cross-modal matching performance (Lachs and Pisoni, 2004a,b).

3 Dynamic characteristics of identity from body movement and actions

Body motion is a pivotal factor in human perception and the recognition of identity (Troje, 2002). Perceivers use body motion to help categorize others' social identities, and these categorizations may carry important consequences such as mate selection (Lick et al., 2013) and prejudice (Johnson et al., 2007). Simplistically, non-rigid body motion can be categorized into: (i) biological motion, which refers to the natural movements of people, like gait or gestures and (ii) motions associated with specific purposeful activities like drinking or sports type actions (Dittrich, 1993).

One of the most studied aspects of body motion in identity recognition is gait analysis. Gait refers to an individual's unique pattern of walking (Whittle, 2007), which possesses measurable properties that remain consistent over time, are observable from a distance and difficult to camouflage (Zhang et al., 2011). These individualized parameters include stride length, step frequency, limb movement, posture and rhythm, which may be used as biometric markers for identity verification or identification, especially within automated security settings (Bastos and Tavares, 2025).

Early work focusing on the recognition of identity from gait used point-light displays (PLDs), where 'lights' are placed on key areas of the body with all other visual cues removed. When static the image appears like a collection of spots, but when the image moves the body becomes apparent. Cutting and Kozlowski (1977) showed that participants were able to correctly identify an individual walker from six friends 38% of the time (also see Troje et al., 2005). Loula et al. (2005) asked participants to make forced choice decisions about whether a PLD was displaying themselves, a friend or a stranger. Results found that self-recognition was best (69% correct) with friend recognition also significantly above chance. Interestingly, the greatest advantage for accurate recognition of self was from more expressive movements like dancing and boxing.

Further work on the role of gait in identity recognition has used impoverished 'natural' image sequences. For example, Stevenage et al. (1999) found that participants were able to use gait to distinguish between six individuals. Additionally, Baragchizadeh et al. (2020) found that participants' were able to make identity matching decisions to unfamiliar people performing the same action (e.g., both walking) or different actions (e.g., walking and boxing) above chance. Further, Simhi and Yovel (2017) asked participants to study people in motion and recognise them from dynamic or multi-static images. Results suggested that dynamic identity signatures may contribute to

person recognition, but only of familiar people previously seen in motion. Finally, Simhi and Yovel (2020) used a virtual reality recognition memory task, with participants learning dynamic identities at study. At test, images were shown dynamic or as a series of multi-statics. At test, dynamic identities with distinctive gaits were recognized more accurately, from a greater distance away, compared to less distinctive walkers. No such effect was found in the multi-static condition, highlighting the importance of dynamic gait to person recognition.

Beyond gait, other elements of body motion, such as hand gestures, posture shifts, and head movements, may also contribute to identity recognition (Pilz and Thornton, 2016). Hand gestures facilitate communication for both the speaker and listener (Wagner et al., 2014). They are known to be idiosyncratic, influenced by cultural and personal habits (Gawne, 2025), making them distinguishable between individuals (see Gillespie et al., 2014). Further, exaggeration of body actions may be particularly important for identification of an individual (Hill and Pollick, 2000). It seems likely that when viewing bodies in motion we are able to use characteristic motion signatures to help identify the individual shown. To summarize, research has established a beneficial role of motion when recognizing familiar people from body movements and actions, centered around idiosyncratic patterns of movement that aid identification.

4 Considerations and future directions

We have outlined the sources of evidence that support the idea of characteristic motion patterns, useful in the recognition of identity. Such characteristics seem to present in the movement of our faces, voices, bodies and actions. Several issues for consideration remain.

First, we need to understand more clearly what we exactly mean by 'characteristic motion patterns'. Here, it is not clear whether 'characteristic' is synonymous with 'distinctive' – in other words, whether characteristic movement patterns need to be unusual or unique to the individual in some way to support recognition. One way to better understand the extent to which the two parameters are related is to examine how variation in the distinctiveness of movement patterns affects the movement advantage. Some people naturally move more distinctively than others, which may mediate the size of any motion advantage (Lander and Chuang, 2005), supporting a possible effect of natural between-person variability in distinctiveness. Other studies have examined whether the movement advantage is affected by manipulating distinctiveness artificially. As with spatially-based distinctiveness (Valentine, 1988), we can also manipulate the distinctiveness of observed motion by caricaturing motion relative to a 'norm'. Furl et al. (2022) used a face space account (Valentine, 1991) where the axes in the multi-dimensional space reflect spatiotemporal dimensions such as speed, displacement, and relative timing. In this work, spatiotemporal caricatures of unfamiliar faces had a minimal effect on identity processing, regardless of whether presented at learning or test. In contrast, Hill and Pollick (2000) found a benefit of caricatures for the recognition of body motion. They trained participants to recognise individuals' arm movements, and then tested them on temporally exaggerated movements made by the same actors. Recognition levels were higher for increasing levels of exaggeration, suggesting that time-based cues were important for identification. Further studies with familiar people and matched methodologies are required to compare the role of distinctiveness of movement cues in face and body identification. Current disparate findings raise the possibility that movement cues might be integrated into identity judgements differently for faces and bodies – at least, when they are unfamiliar.

Second, we should also consider whether there are common dynamic characteristics found across different aspects of a person that are identity specific – a dynamic fingerprint, if you like, that acts as a cue to identity. Research has generally supported a link between visible face motion and the audible sound of the voice, although it is important to note that some people look and sound more similar than others (Smith et al., 2016). But what about other possible links between person specific motion? At the most basic level, for example, does a person who has particularly pronounced facial movements also have similar style body movements. Future work needs to look at whether such commonalities in motion exist – and if they do, what they look like – and how they might be used to create a dynamic fingerprint that aids identification of a person. Future work may explore between-person variability in the usefulness of dynamic signatures for identification. As reviewed above, there is preliminary evidence that some between-person variability in movement characteristics affects the extent to which they benefit recognition (Lander and Chuang, 2005), but there is little research on other factors that might make some people easier to recognise than others (or, conversely, that lead us to perceive their motion as very similar). Here, multivariate time-series modelling of the dynamic parameters of the whole person may facilitate intra- and inter-subject comparison of dynamic movement patterns (Joo et al., 2018). Understanding the relative reliability and usefulness of dynamic information from the face, body, and voice when making identity judgements – and how this relates to their actual use in identification scenarios – could inform human- and computer-based person identification. Crucially, research investigating the integration of different cues (e.g., face and body) needs to focus specifically on moving stimuli: previous work has shown that people allocate attention to faces and bodies differently when they are static (attention primarily to the face) and dynamic (attention to both the face and body) (O'Toole et al., 2011).

Further, in order for dynamic fingerprints to be useful for recognition, we might expect these to be relatively stable across time and context. However, as well as being more useful for some compared with others, the movement of a person might also vary between different viewing instances of the same person. On some occasions a person might move in their typical way, whereas on other occasions they may not. For example, they may be tired, flattening the characteristics of their observed motion. Alternatively, people might naturally exaggerate their movements, either intentionally (e.g., overenunciating speech) or unintentionally (e.g., intense emotional expressions). Surprisingly little work has addressed how this natural variation affects characteristic motion patterns: for example, whether it increases or hinders the usefulness of movement cues for identification, or whether there are certain dynamic cues that remain consistently available across situations. In the domain of emotion recognition, the increased physical movements associated with higher emotional intensity improve emotion recognition performance (e.g., Hess et al., 1997), but to date there has been no research directly examining the effects of natural variations (exaggerations or reductions) of movement on identification.

Third, if we accept the idea of dynamic fingerprints then we need to consider where such information is integrated in the brain. Early neural models of person perception drew a distinction between the processing of invariant and changeable aspects of a person (Haxby et al., 2000). Invariant features like identity were thought to be processed in the occipital and fusiform face areas (OFA and FFA) and the fusiform and extrastriate body areas (FBA and EBA). Whereas the processing of changeable aspects of a person (like eye gaze, expressions etc.) were linked to the posterior superior temporal sulcus (pSTS; O'Toole et al., 2002; Yovel and O'Toole, 2016). Importantly, research has shown the pSTS responds more strongly to dynamic than static faces, while the FFA and OFA show similar responses to static and dynamic faces (Pitcher et al., 2011; Bernstein et al., 2018). The pSTS is also strongly activated in response to biological motion and to human voices and audiovisual speech (Deen et al., 2015), making it likely that this area plays a key role in the processing and integration of dynamic fingerprints (Yovel and O'Toole, 2016). However, the pSTS is likely only one part of a broader network involved in dynamic person representations. Preliminary evidence (with emotional face expressions) suggests that spatiotemporal facial cues may be represented throughout the face-selective and motion-selective networks in the brain in a spatiotemporal version of 'face space' (Furl et al., 2020). Other work has found a relationship between biological motion perception and activation in both pSTS and the ventral premotor cortex (Gilaie-Dotan et al., 2013). Further work examining other forms of facial, biological, and cross-modal dynamic information (Küçük et al., 2024) is needed to confirm the regions, interactions, and mechanisms involved in processing whole-person dynamic cues.

Finally, research needs to take individual differences of perceivers into account when considering the usefulness of dynamic fingerprints for identification. It is well-established that some people are better at static face identification than others (Wilmer, 2017); likewise, there is individual variation in biological motion perception (Miller and Saygin, 2013), and the movement advantage for face recognition (Butcher and Lander, 2017). However, the extent and consistency of individual differences in the movement advantage have not yet been examined. Interestingly, individuals with prosopagnosia – a severe deficit in face recognition – still show a movement advantage for faces (Bennetts et al., 2015; Longmore and Tree, 2013; Steede et al., 2007). This supports the idea, discussed above, that movement cues might act as a complementary source of information when static cues are less reliable. Super-recognizers, who show exceptional face recognition ability (Russell et al., 2009), also show a movement advantage for famous face recognition (Davis et al., 2016). Thus, findings suggest that the ability to extract and use static cues to identity does not align directly with the ability to extract and use facial movement as a cue to identity (notably, there is also no relationship between static face recognition and identification of biological motion in bodies; Noyes et al., 2018). Nor can the movement advantage be linked to underpinning visual processing strategies: recent work found no association between the movement advantage for famous face recognition and differences in eye-movements to static and dynamic faces (Butcher et al., 2025). It may be that other factors, such as sensitivity to biological motion or other spatiotemporal information, might predict individual differences in this skill. Research into these factors, applying not only to faces but recognition of identity from other aspects like gait, body movement etc. is needed. The development of reliable and consistent measures of individual differences in identifying dynamic signatures may be particularly important in applied contexts, where it may be useful to screen for individuals who excel at specific recognition-based tasks (e.g., identifying known suspects on poor-quality video footage; Bate et al., 2021).

5 Conclusion

This mini review explores how characteristic motions contribute to recognizing familiar people. Movement provides structural and identity-specific cues that enhance recognition, especially under challenging conditions or when static information is limited. Research shows that individuals have dynamic identity signatures, which are learned over time and aid recognition. These cues may be consistent across face, body, and voice, forming a 'dynamic fingerprint.' However, more research is needed to clarify the importance of distinctiveness, how stable these motion cues are between- and within-people, how they are processed in the brain, and how individual differences in perceiver affect their use.

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