

COMMENTARY

Stepping into the genetics of biological motion processing

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Person perception (1) and action understanding (2) are complex, interrelated skills at the very heart of our social world. The ability to process biological motion (BM)—to extract information by observing the movement of others (3)—provides one crucial link between these skills, and research into how we perceive moving bodies has contributed greatly to our wider understanding of social cognition/perception (4). It has long been established that BM processing is subserved by a number of mechanisms operating at different perceptual levels that recruit a range of broadly distributed neural networks (2, 4). In PNAS, Wang et al. (5) take an important step forward in showing that at least one of these mechanisms—the ability to perceive local motion signals—is strongly heritable. As described in more detail below, local motion refers to the movement of isolated body parts, in contrast to the global processing of an entire figure. Within the context of a classic twin study design, Wang et al. (5) use behavioral genetic techniques to show that up to 50% of the individual performance variation in processing local BM signals can be accounted for by genetic factors. The study not only adds to our knowledge of specific mechanisms but also hints at how traditional behavioral, physiological, and neuroimaging approaches to the study of BM (2, 4) could be augmented in the future by considering how genetic, epigenetic, and cellular mechanisms also influence ongoing behavior (6, 7).

Gunnar Johansson first demonstrated how the point-light technique could be used to generate experimental stimuli that emphasized human motion rather than human form. By attaching light sources to the major joints and adjusting the contrast levels, Johansson produced simple “point-light” movies in which only the movement of the actor, but not the underlying body form, could be observed (Fig. 1). Johansson’s initial findings on the speed and ease with which human actions could be identified from these displays (3) gave birth to a research field, and his point-light stimuli—typically created via motion-capture technology today—remain the dominant experimental

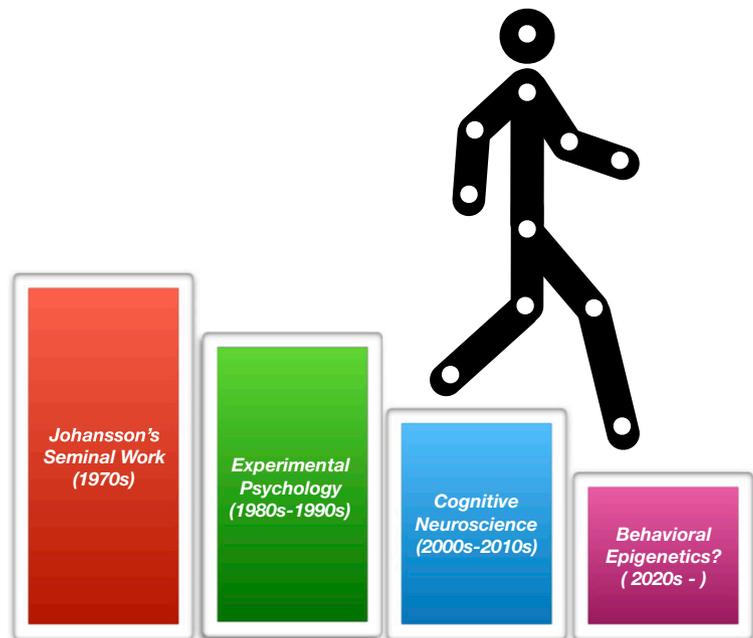


Fig. 1. Important steps in the history of BM research. The human figure illustrates Johansson’s point-light technique (3). In animated displays, even when only the white circles are visible, participants are still able to interpret the individual “points” as belonging to a human figure and to extract a range of socially relevant information (4). The colored steps give a very rough indication of when particular research perspectives began to dominate at the cutting edge of BM research. Clearly, the future influence of behavioral epigenetics (6, 7) on BM research, and more generally on our understanding of cortical information processing, is purely speculative at this point.

tool. Indeed, although modern computer-generated imagery techniques now make it possible to present avatars in which body form is held constant while motion patterns are varied, point-light stimuli remain the preferred way to study BM, probably due to the ability to easily create control conditions, as exploited in PNAS by Wang et al. (5).

The distinction between local and global processing is a common theme in many areas of perception but is made particularly salient in BM studies due to the nature of point-light stimuli. Each individual “point” has a local motion trajectory and to simply

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show observers single points or combinations of points is very straightforward. Another common manipulation, the one employed by Wang et al. (5), is to present all points but spatially scramble their position so that the global organization of the action is disrupted. Previous research using this technique has shown that observers can detect animacy in such displays and can also achieve above-chance performance in determining the facing direction of the underlying action (8). Sensitivity to such local motion trajectories, which appears to be present shortly after birth (9), had already led to the suggestion that our visual system might contain innate “life-detectors,” tuned to detect specific patterns of acceleration consistent with biological agents (10). The finding of Wang et al. (5) that the performance of monozygotic (MZ) twin pairs is much more closely correlated than the performance of dizygotic (DZ) twin pairs on a local BM task clearly adds further weight to the claim that this ability is genetically determined.

More generally, what can be concluded about the mechanism(s) responsible for local BM processing? Conceptually, Wang et al. (5) suggest parallels with the classic CONSPEC system proposed by Morton and Johnson (11) that is thought to provide an innate starting point for the acquisition of face processing skills. Functionally, then, local BM mechanisms may initially serve to orient the infant visual system toward relevant animate stimuli (i.e., a caregiver). Additionally, of course, in mature systems, local BM signals also provide the building blocks out of which a more global percept can be constructed in a bottom-up manner (12). Mechanistically, they almost certainly have much in common with more general low-level motion detection and integration units that make it possible for us to experience nonbiological motion. Indeed, we know from previous research that the perception of local BM motion is governed by similar sets of spatial and temporal constraints (12, 13). There may, of course, be specialized subunits, tuned for specific movement features, such as characteristic acceleration patterns (8). Consistent with the idea of specialized BM detectors, Wang et al. (5) found that performance on the local BM task was worse for participants with high levels of autistic traits and that genetic effects could account for up to 75% of this covariation. There is still some uncertainty as to whether a similar relationship exists between the processing of low-level non-BM motion stimuli and autism (14).

To examine isolated global BM processing, Wang et al. (5) sequentially presented two intervals, each containing “noise masks” or collections of points made up of several spatially scrambled point-light figures. On each trial, one of the intervals also contained a globally coherent walker, shown randomly in 1 of 10 depth orientations. The task was to detect which interval contained the global stimuli. In contrast to the local motion task, performance in this global detection task was completely determined by environmental factors. That is, there were no differences between MZ and DZ pairs that would suggest a direct genetic influence. Perhaps this is not so very surprising. To perform this type of target-in-noise task—which is a standard method used to explore global processing (4)—participants are necessarily informed that a human figure is present and are required to engage in attentionally demanding, top-down strategies (2, 15) in which some type of static (16) or dynamic (17) internal template is matched to the visual input. The potential involvement of such a wide range of cognitive demands and strategies may strongly tip the balance in favor of learned behaviors. Having said that, the complete absence of any genetic influence in the Wang et al. (5) global-only data are admittedly very compelling.

Of course, ordinarily we are not exposed to isolated local or global motion. In a further two experiments, Wang et al. (5)

returned to a simple direction discrimination task in which both local and global processing could be used at once. Accuracy levels were generally better than under isolated conditions, and there was evidence of both genetic and environmental influences on performance. It should be noted, however, that the walkers in these “general” BM experiments were always presented within the context of masking noise. With reference to the comments in the previous paragraph, it would be very interesting to know what happens to this genetic–environment balance when BM is observed without the need for search and figure–ground segregation, that is, without the presence of a mask.

In addition to contributing to our knowledge about local and global mechanisms, the study by Wang et al. (5) also highlights

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two important directions that seem likely to play important roles in future BM research. The first is to emphasize individual differences in performance. Not only does the twin study methodology employed by Wang et al. (5) require examining interclass correlations between pairs of MZ and DZ twins, but as already mentioned, individual BM performance measures were also related to individual measures of autistic traits. There have only been a handful of previous studies that have taken this individual differences approach, for example (18–20). Particularly when special populations are not involved, the vast majority of BM papers look only at group averages. In the same way that new insights have followed in the face perception literature by assuming recognition performance in the general population will be normally distributed (21, 22), BM research may well benefit from further exploring individual differences and their covariation with other perceptual and cognitive skills (18).

The second, and much more fundamental, new direction hinted at by Wang et al., is a shift in the level of explanatory mechanisms that might be entertained. What I mean by this is that BM researchers—together with most of the behavioral neurosciences—have been slow to react to quantum advances that have occurred during the last 25 y in our understanding of neuronal function at the molecular level. Here, I am referring to the establishment of what David Sweatt has termed the “neuroepigenetic” or “behavioural epigenetic” perspective on cognitive function (6, 7). The realization that neurons within the adult CNS are able to rapidly modify gene expression and protein synthesis in response to behaviorally relevant stimuli has major implications for how we conceptualize cortical information processing. While not disputing the role of interneuronal networks, it seems almost certain that intraneuronal processing plays a much more fundamental role in perception and cognition than is typically assumed (23).

Although behavioral epigenetic studies to date have mostly focused on learning and memory processes, there have also been advances in understanding their role in more general human cognitive function and dysfunction. For example, epigenetic mechanisms have been causally implicated in Angelman syndrome, Rett syndrome, Rubinstein–Taybi syndrome, and even autism (6, 7). Recently, the perception–action cycle, in which BM

processing plays a crucial role, has been identified as a key area where tuning of neural ensembles during development is likely to benefit from the influence of epigenetic mechanisms (24). While the current generation of BM researchers have neither the training nor access to practical epigenetic research tools, it is very much

hoped that future neurophysiologically plausible models of BM (25) will be able to give a prominent role to neuron-specific epigenetic mechanisms. With this in mind, Wang et al.'s (5) initial exploration of the genetic basis of BM processing provides a very welcome first step.

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