TOPICS
TOPICS IN COGNITIVE SCIENCE

Topics in Cognitive Science 6 (2014) 567–584

ISSN:1756-8757 print / 1756-8765 online
DOI: 10.1111/tops.12109

Explaining Person Identification: An Inquiry Into the Tracking of Human Agents

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Received 28 October 2013; received in revised form 11 April 2013; accepted 21 April 2013

Abstract

To introduce the issue of the tracking and identification of human agents, I examine the ability of an agent ("a tracker") to track a human person ("a target") and distinguish this target from other individuals: The ability to perform *person identification*. First, I discuss influential mechanistic models of the perceptual recognition of human faces and people (*the face-recognition program*). Such models propose detailed hypotheses about the parts and activities of the mental mechanisms that control the perceptual recognition of persons. However, models based on perceptual recognition are incomplete theories of person identification because they do not explain several identification behaviors that are fundamental to human social interactions (e.g., identifying unobservable persons and imposters). Furthermore, recognition-based models tend to appeal to the controversial concept of the "identity" of a person without explaining what determines personal identity and persistence. To overcome these limitations, I propose to integrate the face-recognition program into a broader causal-historical theory of identification. The causal-historical theory of identification complements models focused on perceptual recognition because it can account for the types of non-perceptual identification overlooked by the face-recognition program. Moreover, it can decompose the identification behaviors into tracking processes that succeed or fail to be sensitive to causal characteristics of a target. I illustrate these advantages with a discussion of the difference between the tracking of a person understood as either a causally continuous biological organism (organism-based tracking) or a psychologically continuous mind (psychological tracking). Finally, I argue that the causal-historical theory provides a theoretical framework for investigating the tracking of relations between a target and its contextual and historical attributes, such as a target's possessions.

Keywords: Agent; Causal cognition; Identification; Mechanism; Person; Personal identity; Persistence; Tracking

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1. Explaining identification behaviors aimed at tracking people

This article aims to provide a critical introduction to several research fields that investigate the ability to track a human agent's identity and persistence over time, and distinguish this agent from other individuals. I discuss both established and novel research programs, including proposals by the other contributors to the present issue of *Topics in Cognitive Science* about the tracking and identification of human agents. The article focuses on what can be termed *person identification* (Thomson, 1981).[1] Interpreting this term broadly, I use it to refer to highly diverse identification behaviors in which a human *tracker*[2] (or inquirer, learner) tracks,[3] recognizes, or discriminates a human *person*—the *target*[4] of the tracker's act of identification. My analysis focuses on works that address questions regarding the foundation of the science of person identification. Specifically, what are the phenomena that should count as cases of person identification, and therefore must be explained by a science of person-identification behaviors? Furthermore, what are the mental and social mechanisms that enable a tracker's ability to identify a person?

According to a commonly held approach, the ability to identify another person primarily depends on mental mechanisms whose functions are to recognize the target organism's face and overall appearance. In Section 2, I present influential models hypothesizing that mechanisms for the recognition of familiar and unfamiliar faces are central to person identification. These models belong to a research program centered on the perceptual recognition of faces, which I term *the face-recognition program* (Bruce & Young, 1986; Calder, Rhodes, Johnson, & Haxby, 2011; Gobbini & Haxby, 2007). In Section 3, I argue that the face-recognition program is incomplete because there is more to human person identification than behaviors driven by perceptual recognition.

The core argument for the view I defend can be introduced by a striking example of spousal misidentification: The notorious[5] case of Martin Guerre (Coras, 1561; Davis, 1983). Martin Guerre was a French peasant born around 1524 in the Basque village of Hendaye who left his wife, child, and village in 1548. In 1556, 8 years after Martin's disappearance, a man claiming to be Martin Guerre—call him "New-Martin"—arrived in the village. For about 3 years, New-Martin resided with Bertrande Guerre (Martin's wife) and Martin's son. After a complaint lodged by a relative, New-Martin came to be suspected of impersonation and was tried in court twice. During the final trial in which the authentic Martin Guerre made a surprising appearance, Judge Jean de Coras (1561) and his associates ruled that New-Martin was an imposter named Arnaud du Tilh. After this revelation and Arnaud's admission of guilt, he was sentenced to death for adultery and fraud, and was executed in 1560.

Arnaud du Tilh impersonated Martin and concealed his real identity from most—possibly all—of the villagers who thought that they had recognized and interacted with Martin for several months. This historical example dramatically illustrates that the perceptual mechanisms for recognizing a person's face and behavior can misidentify a person, and thus fail to identify the intended target.

Although the Martin Guerre case may strike the reader as highly unusual, cases of imposters are in fact well-documented occurrences. They belong to numerous contextual factors that trigger uncertainty in person identification, and make this kind of identification error-prone. Astonishing impostor cases include the impersonation of Nicholas Barclay by Frédéric Bourdin (Grann, 2008) and a number of reciprocal impersonations by lookalikes and twin siblings (Bowyer, 2011; Segal, 1999/2000: p. 93). More significantly from a societal perspective, the activities of both contemporary criminals (e.g., confidence tricksters and cybercriminals) and law enforcers (e.g., undercover police officers (Marx, 1988), informants, and spies) routinely rely on impersonation and communication of false autobiographical narratives. Because impersonations typically require that the target of an identification behavior (e.g., du Tilh) deceives tracker's mechanisms for perceptual and emotional recognition (e.g., one of Martin Guerre's relative), impersonation cases illustrate that a tracker's experience of recognizing a perceived person does not automatically result in successful identification (Mandler, 1980).

After presenting a cluster of arguments establishing that the face-recognition program presents serious limitations (Section 3), I argue that such a program needs to be integrated into a causal-historical theory of identification (Sections 4 and 5). Several of the other contributions to this issue provide treatments of person identification that are broadly consistent with using a causal-historical theory to explain person identification (Brook, 2014; Gelman, Noles, & Stilwell, 2014; Newman, Bartels, & Smith, 2014; Sagi & Rips, 2014).

2. The face-recognition research program

Bruce and Young's (1986) model (Fig. 1), a seminal contribution to the face-recognition program (Calder et al., 2011), has provided a framework for developing a mechanistic approach to recognition-based identification behaviors in both neurologically normal and clinical populations. I use the term "mechanistic explanation" to refer to explanations that aim to account for a target phenomenon by appealing to the components and processes (or operations) of the system that has the propensity to exhibit this phenomenon (Craver, 2007). The mechanistic character of Bruce and Young's model is apparent both in the manner in which the recognition-based identification is decomposed into its components and processes, and in the way more recent models from the face-recognition program refer to neural mechanisms (see, e.g., Gobbini & Haxby, 2007; Fig. 2).

Like other models in cognitive psychology that are based on decomposing the functional parts of a mental system, Bruce and Young's (1986) model aims to account for person-identification behaviors by decomposing the components and processes of a set of identification mechanisms. According to the original model (Fig. 1, components in black and white), the person identification mechanism relies on four key components. First, social interactions lead to perceptual exposure to diverse views of familiar faces. This exposure triggers the encoding of invariant configurations of features, or *structural codes*, which can be contrasted with picture-specific or view-specific codes. Second, *face*

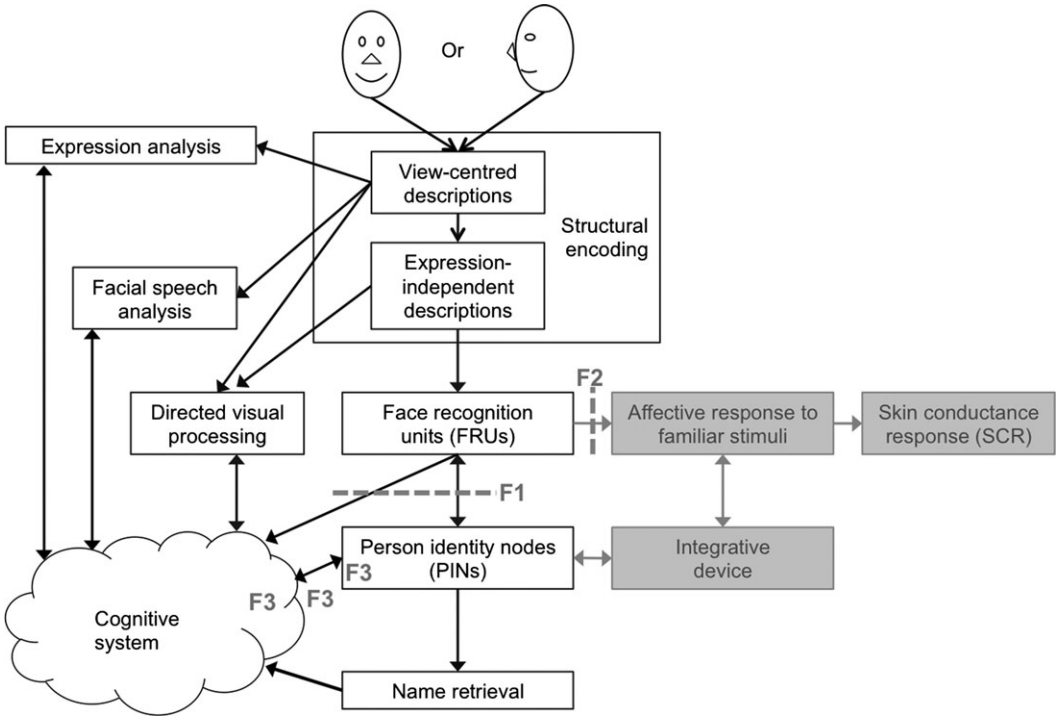

Fig. 1. A mechanistic framework to study person recognition. The schematic combines components from Bruce and Young's (1986) model and Langdon et al.'s (2014; see also Langdon, 2011) account of the factors determining prosopagnosia (F1), Capgras delusion (F2), and Fregoli delusion (F3) (right-hand side boxes and gray arrows).

recognition units (FRUs) assess the familiarity or resemblance of inputs provided by structural encoding, using a store of distinct structural codes. Third, representations of familiar faces stimulate information held by *person identity nodes* (PINs), which store semantic and biographical information that uniquely specifies each of the persons familiar to the agent. Fourth, the PINs provide an input to linguistic processing for *name retrieval*. A number of other processes are performed by the *cognitive system*, the precise characteristics of which are left for further inquiry.

Bruce and Young's (1986) model predicts that the recognition of familiar faces differs from the recognition of unfamiliar faces because it benefits from the processing of structural codes by the FRUs and the information stored by PINs. This difference can account for the fact that participants in laboratory experiments perform face-recognition tasks better when they have to recognize familiar rather than unfamiliar faces. It also suggests a way to account for some errors in person identification (see also Brook, 2014: Section 2; Langdon, Connaughton, & Coltheart, 2014), such as the difficulty that people experience when they have to recognize unfamiliar faces from images like photographic lineups (Lampinen, Neuschatz, & Cling, 2012; Young & Bruce, 2011: p. 962).

The tradition derived from Bruce and Young's (1986) model also adopts a mechanistic approach because it predicts that *specific disorders* of person identification are caused by specific impairments to components and processes in the patient's brain, which can be represented at specific junctures in the posited identification mechanisms. Several models that expand Bruce and Young's (1986) proposal in cognitive neuropsychiatry have supported these predictions with clinical evidence consistent with this mechanistic framework (e.g., Ellis & Young, 1990; Ellis, Young, Quayle, & De Pauw, 1997; Langdon, 2011).

Based on a revision of the models proposed by Bruce and Young (1986) and Ellis and Young (1990), Langdon and colleagues (Langdon, 2011; Langdon et al., 2014) propose a dual-route model for explaining several disorders of person identification. The model predicts that some of the major misidentification delusions are caused by the impairment of mechanisms that control either overt face recognition (e.g., factors F1 and F3 in Fig. 1) or covert face recognition (F2 in Fig. 1). *Prosopagnosia*, a syndrome in which a patient is unable to recognize previously familiar faces, is explained by a disconnect between FRUs and PINs (see F1). This disconnect prevents retrieval of names and biographic information; but it does not impact the covert face recognition associated with affective processing. *Capgras delusional syndrome*, in which a patient adopts the delusional belief that a loved one has been replaced by a lookalike impostor, derives from an impairment to covert recognition (see F2; supporting evidence is reviewed in, e.g., Ellis & Young, 1990; Ellis et al., 1997; Gobbini & Haxby, 2007). Finally, in the case of *Fregoli delusional syndrome*, a delusion in which the patient misidentifies a stranger as a known person in disguise, the delusion derives from the propensity of an impaired "cognitive system" to over-excite certain PINs—see Langdon et al. (2014) for a critical review of the evidence that supports this explanation.

Researchers in cognitive neuroscience have also introduced models that posit brain mechanisms for performing functions associated with FRUs or PINs. In that tradition, Gobbini and Haxby's (2007) model posits two interconnected brain systems (Fig. 2). The first is a *core system* that encodes the visual appearance of faces, performing functions traditionally associated with FRUs. Parts of the core system include the lateral fusiform gyrus, or fusiform face area, which "is involved more in the representation of invariant features of faces and, therefore, presumably plays a role in the recognition of familiar identities" (2007, p. 37). The second is an *extended system* that includes a mechanism for *person knowledge*, which performs functions associated with PINs and the "cognitive system" in Bruce and Young (1986), including the representation of personal traits, mental states, biographical information, and episodic memories.

In contrast to the causal-history theory of identification discussed below (Sections 4 and 5), neither Bruce and Young's (1986) nor Gobbini and Haxby (2007) include causal and contextual reasoning among the core mechanisms for person identification and knowledge.

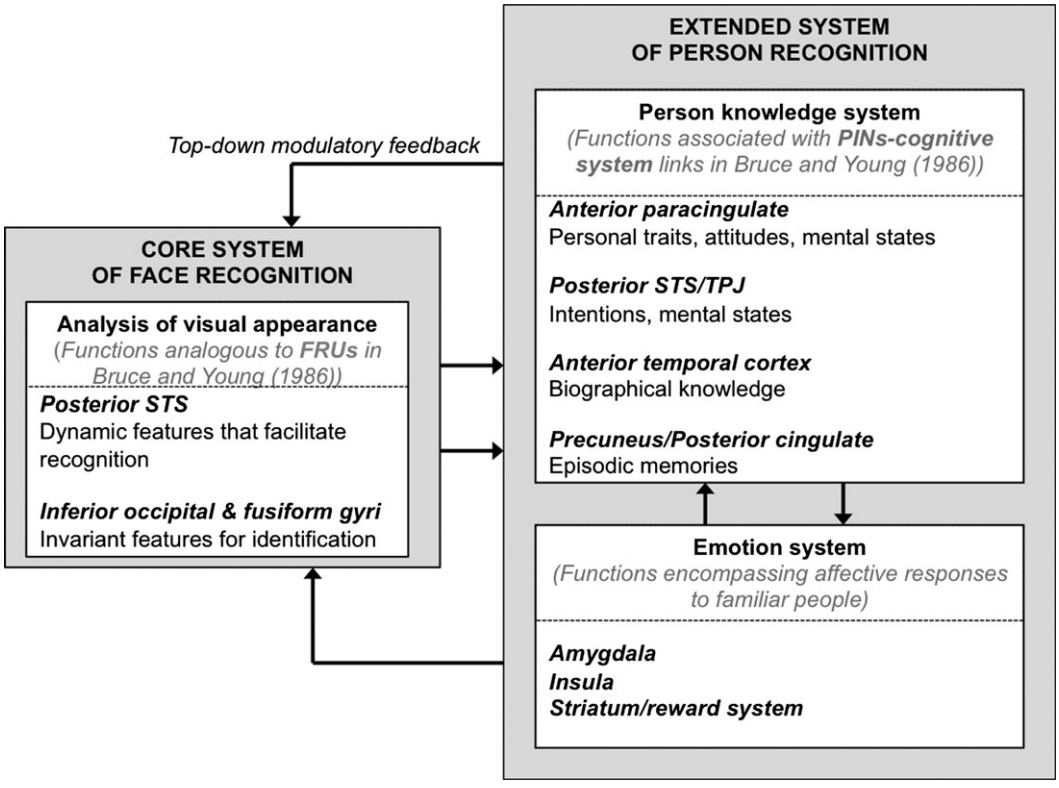

Fig. 2. Outline of Gobbini and Haxby's (2007) model of face recognition and person recognition redrawn with points of comparison with Bruce and Young (1986).

3. The incompleteness of the face-recognition program

The face-recognition program was not initially intended to provide a foundation for a comprehensive theory of person identification. However, the program is currently expanding into an integrative science of person perception (Calder et al., 2011; Young & Bruce, 2011). This extension might lead some researchers to conclude that it provides an adequate framework for developing a comprehensive science of person identification. In this section, I present several arguments suggesting that we should resist this conclusion because the program tends to yield an incomplete image of person-identification behaviors.

A basic idea implying the incompleteness of the face-recognition program is that person identification encompasses a broader set of behaviors than those behaviors driven by the perceptual recognition of the target's organism. For example, person-identification includes those behaviors in which a tracker identifies targets that are unperceived and unobservable, or targets that are tracked via the mediation of linguistic symbols (e.g., a testimony) and pictorial representations (e.g., a video stream on a computer-based social network). If a tracker's target is not directly observable because the target's organism is

situated at a remote place, disguised, or decomposed after death, the tracker must resort to identification strategies that do not use the direct perceptual recognition of the target.

Scholars who seek to account for the history of past social agents and events have to identify human agents without having the means to be perceptually acquainted with such people. An illustration of such a non-perceptual mode of identification is the identification of Richard III of England's remains with bones discovered at Leicester in 2012 (Buckley et al., 2013). This identification resulted from the researchers' causal-historical reasoning about evidence, including historical accounts about Richard III's life and burial site, structural characteristics of the bones, DNA evidence, and radiocarbon dating.

Another case occurs when a tracker begins searching for a target at a location where a living target is absent. Police detectives are often placed in that situation when instigating the search for a perpetrator at a crime scene. Typically, detectives have to rely on methods of indirect identification, such as eyewitness testimonies (Lampinen et al., 2012) and causal/abductive inferences from DNA evidence and latent fingerprints (Cole, 2001)—see the discussion of organism-based tracking in Section 4.

Another source of evidence about the limitations of organism-recognition for identification relates to *discriminative identification*, the ability to discriminate a target from other objects that appear similar or indiscernible (Bullot & Rysiew, 2007; Evans, 1982; Murez & Smortchkova, 2014). Even in circumstances where a tracker is in a position to perceive a target's organism, an *argument from the tracking of causal histories* leads to the conclusion that perceptual recognition does not entail discriminative identification (Bullot, 2014). The argument relies on the following premises:

1. To perform the discriminative identification of a target, a tracker needs to have the ability to track the target's unique causal history—that is, the series of causal facts and interactions that distinguishes the target from any other objects or agents (see Section 4).
2. Mechanisms for the perceptual recognition of a target's face or body do not provide the tracker with an ability to track the target's causal history.

Both premises are credible; and it follows from them that the perceptual recognition mechanisms alone would not provide a tracker with the ability to perform discriminative identification of a target reliably.

To understand one of the fundamental reasons that support the second premise, consider the mechanism linking FRUs and PINs, posited by Bruce and Young's (1986) account of person recognition and its successors (Fig. 1). This mechanism encodes structural differences among faces. As it relies on an organism's visual appearances only, the mechanism alone does not have the discriminative power to differentiate perceptually indiscernible people who have different causal histories such as a number of monozygotic twins (Segal, 1999/2000), accidentally similar people (e.g., Will and William West[6]), and impersonators. Consequently, because the FRU-PIN mechanism lacks contextual information about the distinct causal histories of indiscernible people, it will tend to generate (borrowing the concepts of signal detection theory) "false positive" and "miss" errors when attempting to identify indiscernible people with distinct causal histories. There is

considerable evidence that mistakes in eyewitness identification often involve false positive and miss errors (see, above, Section 2; Lampinen et al., 2012; Thomson 1981), which can only be overcome by reliable causal-historical reasoning (Section 4). In the case of Martin Guerre (Section 1), for example, historical evidence suggests that numerous villagers who were given the task of identifying New-Martin by the judges made false-positive identifications.

Researchers have also to take into account an *argument from the tracking of psychological histories*, which focuses on the "mindreading" ability to ascribe, track, and understand a target's mentality and personality—an ability also referred to as "theory of mind" or "mentalizing" (Apperly & Butterfill, 2009; Bombari et al., 2013; Gergely & Csibra, 2003). Psychological tracking is at the very least relevant, and perhaps sometimes necessary,[7] for identifying a person (Section 4).

Although facial expressions can produce clues relevant to psychological tracking (Porter & ten Brinke, 2010), humans are unable to directly observe and recognize mental a target's mental states and personality. For example, they are unable to directly observe the target's autobiographical memory, feelings, and trustworthiness in contexts involving complex social interactions such as deception (Ekman, 1996; Porter & ten Brinke, 2010), social power (Bombari et al., 2013), and "scaffolded" cooperative cognition (Sterelny, 2012; Sutton, 2010). Consider again the Martin Guerre case: to learn about a target's complex mental and personality traits such as New-Martin's trustworthiness, a tracker needs to learn facts about New-Martin's psychological history that cannot be directly observed. The fact that these psychological phenomena are unobservable highlights the limitations of perceptual recognition (premise 2 of the argument from the tracking of causal histories in Section 3). In a competitive social world, tracking a target's mental characteristics such as the target's trustworthiness requires a flexible, late-developing, and educated system[8] for understanding minds, a system that can appeal to evidence-based reasoning about the target's unobservable causal history (Sections 4 and 5).

The arguments from the tracking of causal and psychological histories are important because, as acknowledged by several theories of the evolution of social cognition (e.g., Sterelny, 2012), human agents live in social contexts where the confounding appearances of "free riders" are a threat for core human institutions. Free riders are agents who seek social benefits without paying for the costs of such benefits. Because free riders threaten institutions based on trust and social justice, it is therefore essential that humans possess the ability to discriminate between agents who act as genuine cooperators and those who act as free riders (e.g., Arnaud du Tilh).

The previous considerations lead to an *argument from cooperative tracking*. Because discriminative identification can be highly challenging for an isolated tracker, humans sometimes develop cooperative methods for identifying people—see, for example, the cooperative methods for organism-based tracking in forensic contexts (Section 4). The individualistic models of person recognition described in Section 2 have not sought to explain how such cooperative methods can expand and bias the mechanisms of person identification (Section 4). They have not sought to account for the fact that person identification is a prerequisite of a variety of practices involving social cooperation such as

authenticating the alleged identity of someone (e.g., unmasking an impersonator), attributing moral and legal responsibility, enforcing commitments and rights (Brook, 2014), and gathering surveillance data about people from social networks (Nissenbaum, 2010).

Finally, an argument *from the concepts of personal identity and persistence* reveals another limitation of the face-recognition program. According to the models discussed in Section 2, face recognition is essentially linked to the tracker's knowledge of "a person's identity." However, it is difficult to interpret what these models imply when they refer to the concept of a person's "identity" because neither Bruce and Young (1986) nor Gobbini and Haxby (2007) provide an explicit analysis of this concept.

Bruce and Young (1986; see Section 2), for example, use as a central concept "personal identity nodes" (PINs) and write that they "are also using face recognition to include what might well be called identification or retrieval of personal information" (p. 305). Thus, in their account, "identification" refers to the retrieval of information about a person's *identity*. However, the authors do not provide a specification of the concepts of a person's identity and personal information. Psychological research on eyewitness identification (e.g., Lampinen et al., 2012) and interpersonal sensitivity (Bombari et al., 2013) tends to overlook this question as well, although the question of personal identity is fundamental to ethical and legal problems associated with person identification (see DeGrazia 2005 and Section 6 in Brook, 2014). In contrast to these theories, I argue in Section 4 that the analysis of a tracker's conceptions of a target person's persistence and causal organization is relevant to the science of person identification.

The analysis of the concept of "personal identity" raises several ontological problems of personal identity, which have been investigated by philosophers. For example, a problem that is closely tied to research on tracking is the *persistence question* (Olson, 2002/2010), also known as the *reidentification question*, which queries what makes a person at time t_0 the same person as a person at time t_{-1} and/or time t_{+1}. The philosophical theories that address the persistence question have investigated a wide range of criteria for personal persistence, including causal contiguity (Nozick, 1981; Rips et al., 2006; Sagi & Rips, 2014), organismic continuity (DeGrazia, 2005; Wilson & Barker, 2007/2013), and psychological connectedness (e.g., Brook, 2014; Parfit, 1984; Shoemaker, 1984).

4. The causal-historical theory of person identification

In the following sections, I propose to integrate the face-recognition program into a broader theory, which posits that the identification of a target relies on the tracking of that target's unique causal history. We may refer to the broader program as *the causal-historical theory of identification* (Bullot, 2014; Bullot & Reber, 2013; Coltheart et al., 2009; Gelman, 2003; Gopnik & Schulz, 2007; Newman et al., 2014; Sagi & Rips, 2014). The causal-historical theory posits that, regardless of whether the tracker prioritizes either perceptual or causal evidence, successful acts of person identification must involve the tracking of certain aspects of the target's causal history (Section 3). This hypothesis should be at the core of a framework that combines recent models of person recognition

(Section 2) with research on causal learning during ontogenetic development (Gopnik & Schulz, 2007; Gutheil, Gelman, Klein, Michos, & Kelaita, 2008) and causal-historical judgments in adults (Brook, 2014; Bullot & Reber, 2013; Gelman, 2003; Rips et al., 2006).

Person-identification behaviors involve behaviors as varied as the fast perceptual recognition of familiar people (Section 2), the time-stressed tracking of people's identities, and trustworthiness in crowded social contexts (e.g., conferences), and long-term cooperative activities for completing archaeological identification (Section 3) and forensic identification (Sections 1 and 3). Because person identification has to be performed in diverse contexts where computational and social constraints vary greatly, humans may resort to a *tool box* strategy, a strategy in which a tracker exploits the sources of evidence—or "tools" for identification—that are available to her at the particular time and context of her decision-making. Next, I examine novel hypotheses suggested by my causal-historical approach, which relate to how a tracker's causal-historical judgment learns to be sensitive to, or fails to be sensitive to, the causal organization of a target (Fig. 3; Section 4) and the target's relations with possessions and contexts (Fig. 3; Section 5).

Consider first how the causal-historical approach can help us build a theory of identification that addresses the problems associated with the concepts of person and personal persistence (see Section 3 and Brook, 2014; Murez & Smortchkova, 2014).

Understood as a causal concept, the concept of a *person's persistence*—or personal identity—can refer to at least two different types of causal histories. The first is the continuity and causal persistence of a particular *living organism* of the species *Homo sapiens* (DeGrazia, 2005). The second type is an agent's psychological history (Section 3); that is, the continuity and causal persistence of an individual as a *psychological self* with mental abilities, such as continuous autobiographical memories and consciousness (Brook, 2014; Shoemaker, 1984).

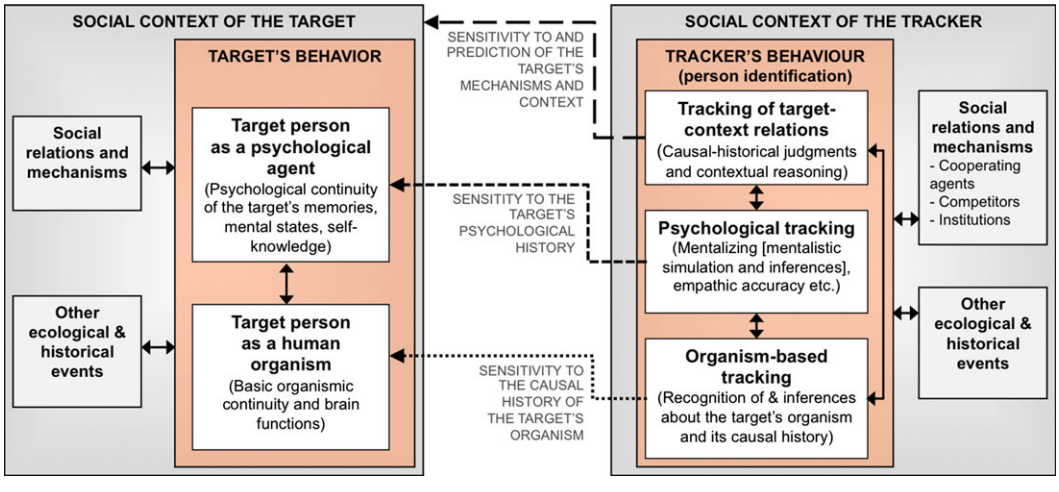

Fig. 3. The causal-historical theory of person identification (see text for details).

An individual *Homo sapiens* in a vegetative state, whose cortical brain cells have died as a result of injury but possess a functioning cerebrum, is a persisting person in the biological sense of being a living organism (DeGrazia, 2005; Wilson & Barker, 2007/2013). However, this individual does not possess the causal organization necessary to qualify as a psychological person, an individual who has the ability to perform mental and cognitive tasks that are continuous with prior memories and mental states (Brook, 2014; Parfit, 1984; Shoemaker, 1984). Because we need to distinguish at least these two ways of persisting as a person, the causal-historical approach can help us distinguish two counterpart types of tracking, organism-based and psychological tracking.

The first type, *organism-based tracking* (Fig. 3, dotted arrow), occurs when a tracker aims to identify a target understood as the same continuing organism (henceforth *person-as-organism*). A tracker performs this type of tracking when he seeks to establish that a person-as-organism is the product of a previously existing person-as-organism, roughly following this causal-historical heuristic:

> To establish that person-as-organism A persists as person-as-organism B, a tracker should aim to establish that the ontogeny of B is a causal product of the biological growth and ontogenetic development of A's organism.

This organism-based tracking requires the tracker to learn to be sensitive to clues of the target's causal persistence as a single organism (dotted arrow in Fig. 3). However, it does not necessitate that the tracker becomes sensitive to the causal persistence of the target's mental states, if any. Abilities that are relevant to carrying out this type of tracking include learning to recognize organisms (Section 2) and learning to reason causally about the target's organism and history (Section 4). Humans have developed a wide range of applied sciences and techniques for supporting cooperative organism-based tracking, which range from the use of anthropometry and fingerprint comparisons (Cole, 2001) to the more recent use of DNA profiling and biometrics for person-identification.

A second type of person-identification behavior is *psychological tracking* understood as the tracking of a person's mentality and agency on the basis of clues of psychological persistence (Fig. 3, dashed arrow). If a tracker aims to search for and identify a target understood as a continuous self or agent (henceforth *person-as-psychological-agent*), then this tracker has to recruit mechanisms for tracking the target's mind and psychological, abilities which are not necessary to perform organism-based tracking. Relevant abilities for this type of tracking include inferring and simulating mental states such as beliefs (Apperly & Butterfill, 2009; Dennett, 1987), desires (Gergely & Csibra, 2003), memories (Brook, 2014), and affective traits (Bombari et al., 2013) from the target's behaviors and traces left by such behavior.

Tracking a person-as-psychological-agent (psychological tracking) requires the tracker to possess a mechanism that can represent and ascribe mental states, such as a "theory of mind" mechanism (Gobbini & Haxby, 2007), a naïve theory for reasoning about rational action (see §4.2 and Gergely & Csibra, 2003), or a mechanism sensitive to the target's autobiographical memory (Brook, 2014). For example, according to Brook (2014), a tracker

who seeks to determine whether person-as-psychological-agent A persists as person-as-psychological-agent B must deploy a mechanism that is sensitive to the target's autobiographical memory, such as a mechanism guided by this causal-historical heuristic:

> To establish that person-as-psychological-agent A persists as person-as-psychological-agent B, the tracker should aim to establish that B's global autobiographical memory causally connects to and depicts A's earlier conscious experience.

The examples and arguments reviewed in Section 3 suggest that the use of causal-historical reasoning for tracking is required by contexts in which the tracker has to cope with uncertainty in the decision-making process—for example, when identifying a target who is difficult to perceive, unfamiliar, or unobservable. To explain how trackers cope with this uncertainty, the causal-historical theory can posit that humans routinely use *causal-historical heuristics*[9] for guiding decision-making about the target's causal history and personal persistence. This hypothesis has not been suggested by leading models of the face-recognition program (Section 3).

It is likely that causal-historical heuristics are associated with subtle interactions between organism-based and psychological tracking (right-hand side of Fig. 3, bidirectional vertical arrows). First, consider the view that a person-as-psychological-agent cannot persist independently of a person-as-organism because common-sense dualism is false (Bloom, 2004; Bullot & Rysiew, 2007). This view suggests that the psychological tracking of a person-as-psychological-agent might often be carried out by causal-historical heuristics that infer mental states from the tracking of a person-as-organism's observable properties.

Second, in the research investigating the intentional stance (Dennett, 1987), several researchers argue that both infants and adults infer mental states (psychological tracking) by relating action, goal-states, and contextual constraints by means of the *principle of rational action*. This principle states that "actions function to realize goal-states by the most efficient means available" (Gergely & Csibra, 2003, p. 287). It implies that the tracker should use the tracking of observable properties of the target's organism (organism-based tracking) and the target's context (target-context relations tracking; Section 5) for inferring unobservable properties of the target's mentality (Baker, Saxe, & Tenenbaum, 2009). Thus, the principle can be used to generate causal-historical heuristics for performing the psychological tracking of a target's mentality from the tracking of the target's organism and context.

Third, in the case of forensic identification (Sections 1 and 3), discovering facts about the causal history of an organism (organism-based tracking) can help trackers identify the suspect's intentions and honesty (psychological tracking). For example, tracking the fact that Arnaud du Tilh was an untrustworthy imposter (psychological tracking) was facilitated by the discovery that two person-as-organisms, with two demonstrably distinct causal histories, were claiming to be Martin Guerre (organism-based tracking)—see Davis (1983).

Consider now Brook's thesis (2014: Section 3) that the primary procedure for tracking a person is psychological tracking—see also, however, Newman et al. (2014 Newman & Bloom, 2014). Brook nonetheless admits that all the psychological continuities that he examines are underpinned by "substantial causal connections" that, in our world, "do run through a single persisting body." This statement suggests that causal-historical heuristics can guide person identification. For example, a tracker may use the (fallible) causal-historical heuristic predicting that if there is one persisting organism, then there is one persisting person-as-psychological-agent—and *vice-versa*.

The previous examples suggest that person-identification behaviors involve *top–down modulatory feedback* from causal-historical heuristics on perceptual recognition. The models from the face-recognition program (Section 2) have not sought to explain person identification as driven by the use of causal-historical heuristics. However, recent research on top–down modulatory feedback (e.g., Bar, 2007; Hohwy, 2013; Nyamsuren & Taatgen, 2013) could provide important tools for developing a theory investigating how causal-historical heuristics can guide and bias person recognition.

A few studies have reported effects of top–down modulation of the perceptual tracking of people elicited by the communication of causal-historical and social information (Allen & Gabbert, 2013; Anderson, Siegel, Bliss-Moreau, & Barrett, 2011; Bombari et al., 2013; Thompson, 1981). For example, Allen and Gabbert (2013) adapted an attentional tracking task (Multiple Identity Tracking paradigm; see Horowitz et al., 2007) to simulate an assault involving social roles such as assailant, bystander, policeman, and victim. They found that participants' attentional tracking was significantly biased: Participants were better at tracking the assailant, bystander, and policemen than they were at tracking the victim.

The causal-historical theory also suggests hypotheses about errors in person-identification. Ideally, person-identification behaviors should be dynamically adjusted as a function of successes and errors in tracking of and predicting a target's causal history. However, when a tracker adopts a strategy based on misleadingly simple heuristics, the tracker may fail to detect any errors occurring during the tracking of a target's causal history. For example, the villagers' misidentification of du Tilh for Martin Guerre could have been influenced by the villagers' adoption of a conformist heuristic that hinders the tracker's detection of her own misidentification errors (Bullot, 2014). More generally, evidence suggests that, when causal-historical reasoning is driven by shallow heuristics, the latter can lead to biases, an illusion of explanatory depth (Rozenblit & Keil, 2002), and perhaps even magical thinking (Newman & Bloom, 2014).

5. Tracking a person's relations with her possessions and other context-specific attributes

The causal-historical theory provides researchers with a framework to investigate how a tracker learns about the causal relations between a target and its sociocultural and economic contexts (Fig. 3; tracking of *target-context relations* represented by a

long-dash arrow). In this issue, this tracking is investigated by three experimental studies.

In the study by Gelman et al. (2014), 3-year-olds and adults were exposed to sets of objects (novel objects with invented labels), one at a time, and learned a new fact about one of the objects (a target object) in each set. In Experiment 1, participants learned either that the target object *belonged to* the participant or that it possessed a *label*. In the next phase, participants were queried about either of the communicated fact of the target object immediately after a change in location and after a delay. The authors' prediction was that participants would focus more on the contextual connection between object and person when the connection involved ownership than when it involved labeling. Gelman et al.'s task required the participant to keep track of a context-specific and historical relation between herself and the target object (and, arguably, the experimenter's action). The results indicate that participants, and most surprisingly 3-year-old children, were very good at this type of context-sensitive tracking of the history of interactions.

In the context of a research program investigating the tracking of people's possessions (Newman & Bloom, 2014), Newman et al. (2014) provide evidence that artworks, a category of highly valued possessions, are tracked by identification judgments in a manner that is similar to the manner in which people are identified. The authors argue that artworks are viewed as physical extensions of the self. In their study, participants weighed physical continuity as important in judgments of persistence over time. Their results seem to be consistent with the hypothesis that highly valued possessions, such as artifacts, can be viewed as extensions of the possessor's personal identity.

In another study of the tracking of target-context relations, Sagi and Rips (2014) argue that causal reasoning plays an essential role in person-identification behaviors. They present an experimental study examining how people determine the antecedent of a pronoun in a sentence pair, such as: "Charlie pursued Paul through the crowd. He caught up a few minutes later." Sagi and Rips hypothesize that such identification judgments primarily depend on processes of reasoning about identity rather than linguistic processes encapsulated from reasoning. In contrast to models that do not address the problem of personal identity (Section 3), Sagi and Rips defend a causal account of identity based on the principle that the identity of an individual over time depends on the causal-historical path connecting the stages of the individual, and more generally on causal closeness (Rips et al., 2006). Sagi and Rips' prediction is that participants reasoned about causal likelihood and the target's causal-historical path (relative to the relevant universe of discourse) to identify the referent of each pronoun. To test this hypothesis, they varied how likely it is that the event of the first sentence would cause the event of the second for each of the two individuals. The results suggest that participants' decisions about the antecedent followed their prediction about the participants' sensitivity to causal likelihood. This is consistent with the hypothesis that causal-historical heuristics guide person identification and discourse processing.

6. Conclusion

Let me return to the foundational questions with which I began. First, what are the phenomena that should count as cases of person identification and thus be explained by a science of person identification? Although influential models have focused on the phenomena of the perceptual recognition of faces and organisms, I have presented several arguments that highlight the importance of investigating social phenomena that stand beyond the perceptual recognition of faces and bodies. These phenomena include the identification of imposters along the use of causal-historical heuristics for guiding identification judgments and search.

Second, what are the mental and social mechanisms that enable a tracker's ability to identify a person? I have proposed that person identification can be studied by decomposing identification behaviors into a variety of tracking mechanisms and processes. To expand the face-recognition research program, I have argued that a number of tracking mechanisms rely on interactions between recognition and heuristic-based thinking about the target's causal history. Such tracking mechanisms can enable a tracker's sensitivity to different aspects of the persistence of a target, including the tracker's sensitivity to organismic facts (organism-based tracking) and mental continuity (psychological tracking).

Acknowledgments

I am grateful to Fred Adams, Andrew Brook, Veronika Coltheart, Anina Rich, Robert M. Ross, Amanda Selwood, Bingqing Wei, and several anonymous reviewers for helpful comments on previous versions of this article. This research was supported by a Discovery Award from the Australian Research Council (DECRA DP120102055).

Notes

1. I use the term *identification* as the overarching concept to refer to the variety of human identification behaviors, which include the mental processes and actions that agents perform to track, recognize, authenticate, and reason about the identities and persistence conditions of individuals.
2. Following Bullot and Rysiew (2007), I use the term *tracker* to refer to the agent who performs an act of identification, or tracking.
3. The terms *tracking* (e.g., Brook, 2014; Bullot & Rysiew, 2007; Horowitz et al., 2007) and *tracing* (e.g., Rips, Blok, & Newman, 2006) are commonly used in cognitive science to denote the ability to become sensitive to or identify a set of targets over a series of temporally distinct encounters.

4. Following Thomson (1981), Cummins (1996), Ekman (1996), among others (e.g., Bombari, Schmid Mast, Brosch, & Sander, 2013), I use the term *target* to refer to the *entity aimed at* by an identification behavior.
5. Like other famous impostor cases involving impersonation (e.g., Frank Abagnale, Frédéric Bourdin) or forgery (e.g., Han van Meegeren, Elmyr de Hory), the case of Martin Guerre has inspired narrative artworks, including several cinematographic or theatrical adaptations.
6. The indiscernable appearances of Will and William West are allegedly what have caused the abandonment of the Bertillon system in favor of Galton's fingerprinting system as a technique for forensic identification (see Cole, 2001: p. 140-142).
7. Brook (2014) defends the controversial claim that psychological tracking is a necessary and particularly important condition for person identification.
8. See Apperly and Butterfill (2009) for an analysis of the contrast between early-developing and late-developing mindreading mechanisms.
9. Heuristics are reasoning shortcuts that are thought to play a fundamental role in human thinking and decision-making (Gigerenzer & Brighton, 2009).

References

Allen, R., & Gabbert, F. (2013). Exogenous social identity cues differentially affect the dynamic tracking of individual target faces. *Journal of Experimental Psychology: Learning, Memory and Cognition*. *39*(6), 1982–1989. doi: 10.1037/a0033570

Anderson, E., Siegel, E. H., Bliss-Moreau, E., & Barrett, L. F. (2011). The visual impact of gossip. *Science*, *332*(6036), 1446–1448. doi: 10.1126/science.1201574.

Apperly, I. A., & Butterfill, S. A. (2009). Do humans have two systems to track beliefs and belief-like states? *Psychological Review*, *116*(4), 953–970. doi: 10.1037/a0016923.

Baker, C. L., Saxe, R., & Tenenbaum, J. B. (2009). Action understanding as inverse planning. *Cognition*, *113* (3), 329–349. doi: http://dx.doi.org/10.1016/j.cognition.2009.07.005

Bar, M. (2007). The proactive brain: Using analogies and associations to generate predictions. *Trends in Cognitive Sciences*, *11*(7), 280–289. doi: http://dx.doi.org/10.1016/j.tics.2007.05.005

Bloom, P. (2004). *Descartes' baby: How the science of child development explains what makes us human*. New York: Basic Books.

Bombari, D., Schmid Mast, M., Brosch, T., & Sander, D. (2013). How interpersonal power affects empathic accuracy: Differential roles of mentalizing versus mirroring? *Frontiers in Human Neuroscience*, *7*, 375. doi: 10.3389/fnhum.2013.00375.

Bowyer, K. W. (2011). What surprises do identical twins have for identity science? *Computer*, *44*, 100–102.

Brook, A. (2014). Tracking a person over time is tracking what? *Topics in Cognitive Science*, doi: 10.1111/tops.12107. this issue

Bruce, V., & Young, A. W. (1986). Understanding face recognition. *British Journal of Psychology*, *77*, 305–327.

Buckley, R., Morris, M., Appleby, J., King, T., O'Sullivan, D., & Foxhall, L. (2013). 'The king in the car park': new light on the death and burial of Richard III in the Grey Friars church, Leicester, in 1485. *Antiquity*, *87*(336), 519–538.

Bullot, N. J. (2014). Agent tracking: A psycho-historical theory of the identification of living and social agents. *Biology & Philosophy*, 1–24. [online first]. doi: 10.1007/s10539-014-9447-x

Bullot, N. J., & Reber, R. (2013). The artful mind meets art history: Toward a psycho-historical framework for the science of art appreciation. *The Behavioral and Brain Sciences*, *36*(02), 123–137. doi: 10.1017/S0140525X12000489.

Bullot, N. J., & Rysiew, P. (2007). A study in the cognition of individuals' identity: Solving the problem of singular cognition in object and agent tracking. *Consciousness and Cognition*, *16*(2), 276–293. doi: http://dx.doi.org/10.1016/j.concog.2006.09.006

Calder, A. J., Rhodes, G., Johnson, M. H., & Haxby, J. V. (Eds.) (2011). *Oxford handbook of face perception*. Oxford, England: Oxford University Press.

Cole, S. A. (2001). *Suspect identities: A history of fingerprinting and criminal identification*. Cambridge, MA: Harvard University Press.

Coltheart, M., Menzies, P., & Sutton, J. (2009). Abductive inference and delusional belief. *Cognitive Neuropsychiatry*, *15*, (1-3), 261–287. doi:10.1080/13546800903439120

Coras, J. d. (1561). *Arrest Memorable du Parlement de Tolose, Contenant Vne Hiftoire prodigieufe d'un supposé mari, aduenuë de noftre temps*. Lyon: Barthelemi Vincent.

Craver, C. F. (2007). *Explaining the brain: Mechanisms and the mosaic unity of neuroscience*. Oxford, England: Oxford University Press.

Cummins, R. (1996). *Representations, targets, and attitudes*. Cambridge, MA: MIT Press.

Davis, N. Z. (1983). *The return of martin guerre*. Cambridge, MA: Harvard University Press.

DeGrazia, D. (2005). *Human identity and bioethics*. Cambridge, England: Cambridge University Press.

Dennett, D. C. (1987). *The intentional stance*. Cambridge, MA: MIT Press.

Ekman, P. (1996). Why don't we catch liars? *Social Research*, *63*(3), 801–817. doi: 10.2307/40972316.

Ellis, H. D., & Young, A. W. (1990). Accounting for delusional misidentifications. *The British Journal of Psychiatry*, *157*(2), 239–248. doi: 10.1192/bjp.157.2.239.

Ellis, H. D., Young, A. W., Quayle, A. H., & De Pauw, K. W. (1997). Reduced autonomic responses to faces in Capgras delusion. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *264* (1384), 1085–1092. doi: 10.1098/rspb.1997.0150.

Evans, G. (1982). *The varieties of reference*. Oxford, England: Oxford University Press.

Gelman, S. A. (2003). *The essential child: Origins of essentialism in everyday thought*. Oxford, England: Oxford University Press.

Gelman, S. A., Noles, N. S., & Stilwell, S. (2014). Tracking the actions and possessions of agents. *Topics in Cognitive Science*, doi: 10.1111/tops.12106 [Epub ahead of print]. this issue

Gergely, G., & Csibra, G. (2003). Teleological reasoning in infancy: The naive theory of rational action. *Trends in Cognitive Sciences*, *7*(7), 287–292.

Gigerenzer, G., & Brighton, H. (2009). Homo heuristicus: Why biased minds make better inferences. *Topics in Cognitive Science*, *1*(1), 107–143. doi: 10.1111/j.1756-8765.2008.01006.x.

Gobbini, M. I., & Haxby, J. V. (2007). Neural systems for recognition of familiar faces. *Neuropsychologia*, *45*(1), 32–41. doi: 10.1016/j.neuropsychologia.2006.04.015.

Gopnik, A., & Schulz, L. (Eds.) (2007). *Causal learning: Psychology, philosophy, and computation*. Oxford, England: Oxford University Press.

Grann, D. (2008). The chameleon: The many lives of Frédéric Bourdin. The New Yorker, Available at http://www.newyorker.com/reporting/2008/2008/2011/080811fa_fact_grann. Accessed August 11, 2013.

Gutheil, G., Gelman, S. A., Klein, E., Michos, K., & Kelaita, K. (2008). Preschoolers' use of spatiotemporal history, appearance, and proper name in determining individual identity. *Cognition*, *107*, 366–380.

Hohwy, J. (2013). *The predictive mind*. Oxford, England: Oxford University Press.

Horowitz, T. S., Klieger, S., Fencsik, D., Yang, K., Alvarez, G., & Wolfe, J. (2007). Tracking unique objects. *Attention, Perception, & Psychophysics*, *69*(2), 172–184. doi: 10.3758/bf03193740.

Lampinen, J. M., Neuschatz, J. S., & Cling, A. D. (2012). *The psychology of eyewitness identification*. New York: Taylor & Francis.

Langdon, R. (2011). Delusions and faces. In A. J. Calder, G. Rhodes, M. H. Johnson, & J. V. Haxby (Eds.), *Oxford handbook of face perception*. Oxford, England: Oxford University Press.

Langdon, R., Connaughton, E., & Coltheart, M. (2014). The Fregoli delusion: A disorder of person tracking and identification? *Topics in Cognitive Science*, doi: 10.1111/tops.12108. this issue

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, *87*(3), 252.

Marx, G. T. (1988). *Undercover: Police surveillance in America*. Berkeley: University of California Press.

Murez, M., & Smortchkova, J. (2014). Singular thought: Object files, person files and the sortal PERSON. *Topics in Cognitive Science*, doi: 10.1111/tops.12110. this issue

Newman, G. E., Bartels, D., & Smith, R. (2014). Are artworks more like people than artifacts? Individual concepts and their extensions. *Topics in Cognitive Science*, doi: 10.1111/tops.12111. this issue

Newman, G. E., & Bloom, P. (2014). Physical contact influences how much people pay at celebrity auctions. *Proceedings of the National Academy of Sciences*, *111*(10), 3705–3708. doi: 10.1073/pnas.1313637111.

Nissenbaum, H. F. (2010). *Privacy in context: Technology, policy, and the integrity of social life*. Stanford, CA: Stanford University Press.

Nozick, R. (1981). *Philosophical explanations*. Cambridge, MA: Harvard University Press.

Nyamsuren, E., & Taatgen, N. A. (2013). Set as an instance of a real-world visual-cognitive task. *Cognitive Science*, *37*(1), 146–175. doi: 10.1111/cogs.12001.

Olson, E. T. (2002/2010). Personal identity. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Winter 2010 Edition). Stanford, CA: Metaphysics Research Lab, CSLI, Stanford University. Available at http://plato.stanford.edu/archives/win2010/entries/identity-personal/. Accessed January 18, 2013

Parfit, D. (1984). *Reasons and persons*. Oxford, England: Oxford University Press.

Porter, S., & ten Brinke, L. (2010). The truth about lies: What works in detecting high-stakes deception? *Legal and Criminological Psychology*, *15*(1), 57–75.

Rips, L. J., Blok, S. V., & Newman, G. (2006). Tracing the identity of objects. *Psychological Review*, *113* (1), 1–30.

Rozenblit, L., & Keil, F. (2002). The misunderstood limits of folk science: An illusion of explanatory depth. *Cognitive Science*, *26*(5), 521–562. doi: 10.1207/s15516709cog2605_1.

Sagi, E., & Rips, L. J. (2014). Identity, causality, and pronoun ambiguity. *Topics in Cognitive Science*, doi: 10.1111/tops.12105. [Epub ahead of print]. this issue

Segal, N. L. (1999/2000). *Entwined lives: Twins and what they tell us about human behavior*. New York: Plume, Penguin Group US.

Shoemaker, S. (1984). Personal identity: A materialist account. In S. Shoemaker & R. Swinburne (Eds.), *Personal identity* (pp. 67–132). Oxford, England: Basil Blackwell.

Sterelny, K. (2012). *The evolved apprentice: How evolution made humans unique*. Cambridge, MA: MIT Press.

Sutton, J. (2010). Exograms and interdisciplinarity: History, the extended mind, and the civilizing process. In R. Menary (Ed.), *The extended mind* (pp. 189–225). Cambridge, MA: MIT Press.

Thomson, D. M. (1981). Person Identification: Influencing the Outcome. *Australian & New Zealand Journal of Criminology*, *14*(1), 49–54. doi:10.1177/000486588101400106

Wilson, R. A., & Barker, M. J. (2007/2013). The biological notion of individual. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (Spring 2013 Edition). Stanford, CA: Metaphysics Research Lab, CSLI, Stanford University. Available at: http://plato.stanford.edu/entries/biology-individual/. Accessed January 22, 2013

Young, A. W., & Bruce, V. (2011). Understanding person perception. *British Journal of Psychology*, *102*(4), 959–974. doi: 10.1111/j.2044-8295.2011.02045.x.