ABSTRACT

Title of Dissertation:	Children's Developing Representations of Physical and Social Power
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When navigating unfamiliar social environments, it is important to identify who is powerful. Knowing who has power can be challenging because there may be limited social information available to an observer, and because people achieve influence for many reasons. In experiments with 3- to 5-year-old children (n = 192) and adults (n = 32), we investigated the developmental origins and conceptual structure of power judgments based on physical appearance. First, we examined participants' judgments of strength and authority from facial structure and expansive body posture; next, we used a matching task to assess whether children thought that powerful faces and bodies "go together". With age, children became increasingly sensitive to these two appearance cues and viewed both as evidence for both strength and authority. Unlike children, however, adults did not attribute strength to expansive body postures. Moreover, by 4 years, children brought facial and postural information together, indicating that they have formed a single, coherent representation of how

they think powerful people appear. Overall, children's sensitivity to postures preceded faces and their attributions of strength preceded authority, suggesting that an early capacity for assessing formidability may support later-emerging notions of power that are determined in a more normative manner.

CHILDREN'S DEVELOPING REPRESENTATIONS OF PHYSICAL AND SOCIAL POWER

by

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Chapter 1: Literature Review

"Power" refers to the ability to exert control over others (Ellyson & Dovidio, 1985). Whether a surgeon delegates tasks and coordinates the activates of her assistants in the operating room, or a child forcefully determines the game that will be played at recess, both the surgeon and the child are acting from a position of relative power.

In human societies, differences in power arise from many sources. For example, two people might differ in power because of their relative ages, wealth, social status, or their physical and intellectual capabilities. Frequently, people differ along multiple dimensions (Sidanius & Pratto, 1999). Thus, differences in power are underlain by a variety of individual- and group-level factors guaranteeing that leaders will emerge from group interactions (Magee & Galinksy, 2008).

"Hierarchy" refers to the distribution of power within social groups (Magee & Galinsky, 2008). In principle, power can be distributed in multiple ways, ranging from near egalitarianism in which individuals exercise roughly equal control over one another, to total dictatorships in which a single individual exerts ultimate control. In practice, neither of these extremes is commonplace. Regardless of their size or stated organizational preferences, social groups almost always exhibit a stratified and asymmetric structure. A few individuals occupy the top of the hierarchy while the majority of group members occupy lower positions (Anderson & Brown, 2010; Anderson & Kilduff, 2009; Magee & Galinsky, 2008; Van Berkel, Crandall, Eidelman, & Blanchar, 2015).

Power hierarchies are pervasive in both human and animal societies, influencing the social relationships and well-being of individuals at every level of social organization (Anderson, Hildreth, & Howland, 2015; Barkow, Akiwowo, & Barua, 1975; Sapolsky, 2005). One reason for this pervasiveness is that hierarchies facilitate social order and coordination. When hierarchies are clearly defined, they remove the guesswork of who will coordinate the groups' actions or how resources will be allocated. This allows individuals to focus on completing tasks rather than planning them, and to seek their own resources rather than scrambling over what will be taken away. The positive benefits of hierarchy are apparent when comparing the efficiency and output of organizations exhibiting different power structures. For example, hierarchically organized groups achieve greater efficiency and output than those in which power is distributed laterally. Hierarchies are particularly effective when the processes that establish their internal structure are deemed legitimate by those affected (Anderson et al., 2015; Chiao, Mathur, Harada, & Lipke, 2009). In sum, hierarchies satisfy a suite of humans' psychological needs for social structure, stability, and collaboration with others to achieve necessary ends (Henley, Horsfall, & De Soto, 1969). Thus, many animal species possess psychological capacities that allow them to represent the local distribution of power within highly familiar groups.

In nonhuman animals, power hierarchies are heavily influenced by the threat of violent conflicts. For example, in many primate species, conflicts over necessary resources have the potential to escalate into physical combat and these conflicts are naturally settled in favor of the physically stronger of two individuals (Weisfeld & Beresford, 1982). After repeated conflicts, an individual's accumulated ratio of wins

and losses influences his or her position within the local power hierarchy. The strongest individuals become socially central. They are capable manipulating others' behaviors, and also enjoy privileged access to necessary resources like food and mating opportunities. The more diminutive, less formidable group members continually struggle to obtain these benefits (Sapolsky, 2005).

Though an individual's position within a local hierarchy may not be wholly determined by formidability, this particular trait has been considered crucial for obtaining power. Formidability bears directly on an organism's ability to both acquire and retain necessary resources (referred to in ethological literature as an organism's resource holding potential (Arnott & Elwood, 2009; Parker, 1974). This relation between formidability and social rank in primate communities is easily generalized to other animal species (Arnott & Elwood, 2009). To mitigate the potentially fatal costs of combat, many species have developed a variety of cognitive and behavioral strategies to resolve social conflicts before they escalate into violence. In primates, these include the ability to accurately infer another's physical formidability by assessing inherent physical features like overall size, musculature, tooth size, and facial structure. In addition, primates respond to the nonverbal behaviors and emotional expressions of others. For example, when conflicts arise, many primates will adopt erect and expansive posture, make loud whooping calls and screams, or exhibit some combination of size enhancing and noise making behaviors (Weisfeld & Beresford, 1982). When group members mutually attend to the physical and behavioral cues of others and respond these cues similarly, they become capable of engaging in advantageous decision making such as deciding to initiate or retreat from

conflict. So long as the results of such decision-making processes remains adaptive, they have the potential to become normative. That is, individuals groups may develop ritualized behaviors and manners of attention that ultimately contribute to group coherence by avoiding genuine physical conflicts.

Despite our shared evolutionary history with nonhuman primates, in human societies, differences in power arise from a much broader range of sources. In fact, the dimensions on which hierarchical differentiation can occur appear to be limited only by the subjective values of those involved (Magee & Galinksy, 2008). Despite this complexity, the need to make adaptive inferences about others physical capabilities and their social roles is no less significant in human societies than it is across the rest of the natural world.

Judgements of Power in Adults' Impression Formation

Many organisms make adaptive predictions about the environment in order to survive. This is especially true of the social environment, where misjudging the intentions or social dispositions of others can have severe consequences (Ames, et al., 2007; Bar, 2007). One strategy for evaluating others is to be cautious: to withhold judging whether a person is good or ill-intentioned until after observing their behaviors and interactions across multiple contexts. However, in many cases we do not have the convenience of this strategy. "Never judge a book by its cover" the saying goes, but circumstances commonly force us to do otherwise.

Whether it is the first day in the work place or the first day in the prison yard, people are forced to arrive at fast and consequential first impressions about the people that they encounter. Adults' initial impressions of others are supported by fast and

intuitive processes (Bar, Neta, & Linz, 2006; Rule, Adams, Ambady, & Freeman, 2012; Todorov, Pakrashi, & Oosterhof, 2009) based on others' physical appearance, postural expressions, and brief instances of behaviors for impression formation to occur (Ambady & Rosenthal, 1992; Ambady, Hallahan, & Rosenthal, 1995; Bar, 2007; Borkenau, Mauer, Riemann, Spinath, & Angleitner, 2004; Brey & Shutts, 2014; Carney et al., 2005; Carney, Colvin, & Hall, 2007; Knutson, 1996; Todorov, Mende-Siedlecki, & Dotsch, 2013; Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015; Todorov, Said, Engell, & Oosterhof, 2008; Willis & Todorov, 2006; Zebrowitz & Montepare, 2008). These intuitive judgments provide information for immediate decisions like approach and avoidance, as well as information for more deliberative decisions like voting (Little, Burriss, Jones, & Roberts, 2007; Little, Roberts, Jones, & DeBruine, 2012).

Adults' initial impressions of others generally fall along two orthogonal dimensions: "trustworthiness" and "dominance". The "trustworthy" dimension characterizes adults' initial impressions of others' behavioral intentions as either helpful or harmful (Oosterhof & Todorov, 2008; 2009; Sutherland, Oldmeadow, & Young, 2016; Sutherland et al., 2013; Todorov et al., 2015). People that are perceived as "trustworthy" are imbued with positive behavioral intentions while people perceived as "untrustworthy" are imbued with negative intentions. Because attributions of trustworthiness are heavily influenced by the similarity of a person's inherent features to more dynamic emotional expressions, researchers have described these attributions as overgeneralizations from temporary emotional states (e.g., happy, nice, sad, mean: Todorov et al., 2015; Zebrowitz & Montepare, 2008). The

"dominance" dimension characterizes adult's initial impressions of others' ability to carry out their helpful or harmful intentions. People that are highly "dominant" are imbued with enduring character traits (e.g., a desire to control and influence others), physical capabilities (e.g., like being physically strong), and social rank (e.g., being "in charge") that make them socially "potent" and effective in achieving their goals (Ellyson & Dovidio, 1985).

Adults' attributions of "dominance" are heavily influenced by the presence of mature and prototypically masculine physical features. Thus, attributions of "dominance" are closely related to evaluations of physical formidability rather than simple overgeneralizations from emotional expressions. The terms "trustworthiness" and "dominance" capture a rang of inter-correlated impressions. For example, the "dominance" dimension captures adult's initial impressions of either a person's formidability, or their impressions of a person's social rank. In general, people that are perceived as highly dominant are also perceived as more likely to occupy a position of authority. However, influential models of status attainment suggest that most leaders acquire their status through less aggressive means: either by communicating superior competence or demonstrating superior skills relative to others (Anderson & Kilduff, 2009; Chen, Jing, & Lee, 2014; Hardy & Van Vugt, 2006; Henrich & Gil-White, 2001; Kennedy, Anderson, & Moore, 2013; Van Vugt, 2006). This suite of traits is commonly referred to as "competence" or "prestige" and communicating these traits to others reflects a viable strategy for status attainment (Cheng, Tracy, & Henrich, 2010; Cheng, Tracy, Foulsham, Kingstone, & Henrich, 2013). Thus, while a person's real-world status or rank and dominant tendencies may

be negatively correlated in practice, they are highly correlated in adults' initial impressions of others.

Below, I discuss some of the evidence demonstrating that adults' attributions of status and dominance are inter-correlated in their initial impressions of others. First, I describe work on adults' impressions of dominance as it refers to others' strength and formidability. Second, I describe adults' initial impressions of dominance as it refers to others' social rank and authority. Third, I discuss research demonstrating that adults' use information about strength and formidability to form initial impressions about social rank. However, these relations have been primarily observed in adult's judgments from emotionally neutral faces (Sutherland et al., 2013; Todorov et al., 2015).

Adults' impressions of physical strength and formidability

To avoid the potential consequences of misjudging a person's formidability, adults frequently estimate the strength-related capacities of others the moment that they first encounter them. We gain insight into the nature of the representations supporting these judgments by examining adults' attributions of strength from others inherent physical appearance. For example, Sell and colleagues (2009) asked American adults to estimate the physical strength and fighting capacities of an ethnically diverse range of males and females. In these photographs, each person was standing in a relaxed posture, and dressed so that the musculature of their arms and legs were clearly visible. Prior to being photographed, both the upper and lower body strength of each person was measured via a battery of standardized weight lifting measures. These measurements were used as a positive check on adult's impressions.

In addition, the people in each photograph provided information about the frequency of their fighting behaviors in the last two years. Subsequent analyses revealed that participants formed consistent impressions about each person. Their estimates of both strength and formidability were highly correlated with the real-world strength and fighting behaviors of each person. Thus, adults have shared expectations about the physical appearance of people that are strong and formidable, and these representations contain (at least) information about the appearance of physical features organized around the arms and legs.

Though adults' impressions of strength were most accurate when looking at images of people's entire bodies, they also formed consistent and accurate impressions of strength when looking at people's faces alone (Sell et al., 2009). The inherent facial features that give rise to adults' impressions of strength have been well characterized (Carré, McCormick, & Mondloch, 2009; Cogsdill et al., 2014; Holzleitner & Perrett, 2016; Oosterhof & Todorov, 2008; Toscano et al., 2014; 2016) and are often described as being prototypically "masculine".

Results like these suggest that adults need not observe direct evidence about a person's physical strength or prowess in physical conflict to infer these capabilities. Rather, adults attribute strength and formidability to people based on inherent features distributed across both the face and the body. Moreover, adults' representations of strong appearance are general enough to be applied to both culturally familiar – i.e., U.S. college students – and unfamiliar people - i.e., Andean and Bolivian men from small pastoral communities (Sell et al., 2009), suggesting that the inherent features that signal physical strength are universal.

Adults' impressions of social power and authority

To avoid the potential consequences of misjudging the presence of an authority figure, adults form spontaneous impressions about the nature of a person's social rank and influence from the moment that they first encounter them. For example, adults are more likely to interpret a person as being socially powerful when they possess prototypically mature and masculine facial features (Cogsdill et al., 2014; Keating & Bai, 1986; Keating, Mazur, & Segall, 1977; Toscano et al., 2014).

Adults also form consistent impressions about which of two people is "in charge" or more "powerful" based on differences in their nonverbal behaviors and postural expressions (Abele, Cuddy, Judd, & Yzerbyt, 2008; Brey & Shutts, 2014; Burgoon & Dunbar, 2000; Carney et al., 2005; 2007; Cashdan, 1998). Specifically, adults interpret a person with broad and expansive posture as more likely to occupy a position of authority relative to someone that exhibits more diminutive and restrictive posture. Expansive posture not only gives the impression of a person with authority, but also causes others to engage in spontaneous subordinating behaviors like averting attention away from the face of people in expansive postures (Holland, Wolf, Looser, & Cuddy, 2017) or adopting submissive postures themselves (Tiedens & Fragale, 2003). These spontaneous behaviors that occur in simulated first-person interactions are also utilized to make inferences about social structure in third party interactions (Cheng et al., 2013; Dovidio and Ellyson, 1985; Foulsham, Cheng, Tracy, Henrich, & Kingstone, 2010). Specifically, adults interpret a person who engages in prolonged eye contact with another person while speaking as more likely

to occupy a position of authority relative to someone who tends to look away from the other person while speaking.

In addition to attributing relative authority to people based on these cues, adults spontaneously generate expectations for these nonverbal behaviors (Carney et al., 2005). For example, when asked at different times to imagine a person of high authority and a person of low authority, adults' described people with high authority as more likely to have "open" postures and to engage in direct visual contact with others. People that occupied positions of low authority were described as more likely to have "restrictive" postures and avoid eye contact with others.

Results like these suggest that adults need not observe others' behaviors (e.g., one person gives commands and the other obeys) to make inferences about their relative social roles. Rather, adults attribute different social roles to people based on observable (or imaginable) differences in the way that people carry themselves. But why does relative posture lead to attributions of relative social rank?

Unlike neutral faces, postural expressions provide fairly direct evidence about the current emotional states of the people enacting them (Burgoon & Dunbar, 2000; Cashdan, 1998; Nelson & Russell, 2012). For example, a person with their arms "akimbo" and legs spread apart is interpreted cross culturally by adults as expressing pride, while restrictive posture is interpreted as expressions shame (Tracy & Robins, 2007). Thus, differences in posture may provide insight into the relative rank of two people because of beliefs that social rank establishes norms surrounding the expression of emotion, particularly emotions of pride and confidence. Because adults interpret postures as expressing a person's current emotional state, then there should

be limits on the variety of power-relevant judgments that adults make from this cue. For example, while adults attribute both relative strength and status on the basis of differences in inherent facial structure, there are no studies assessing whether adults also attribute relative strength on the basis of posture. This is surprising, since researchers have long appreciated that attributions of relative rank can be supported by a variety of power-relevant attributions. Future work comparing which power-relevant attributions adults make to either inherent cues like facial structure or more dynamic cues like postural expressions may shed light on the underlying structure of adults' perceptions of power.

Underlying Structure of Power Attributions

Though being "strong" and being "in charge" do not mean the same thing, there is overlap in the physical cues that engender both attributions. For example, adults attribute greater social power and physical strength to the same people. Lukaszewski and colleagues (2016) presented U.S. participants with photos of ethnically diverse males and females. The participants of this study were told that the individuals in each photo were recently hired by a small business consultancy, but that the specific role of each person was yet to be determined. Participants were instructed to provide ratings of each persons' physical strength – defined as being strong relative to people of the same age, projected social status – defined as a person's likely future standing within the consultancy, and leadership qualities – defined as the ability to organize their potential colleagues' activities and to represent the consultancy in face-to-face meetings. Similar to the study conducted by Sell and colleagues (2009), prior to being photographed, the people in each photograph

completed a battery of standardized weight lifting measures which were used as a positive check against adults' impressions of physical strength and as a predictor of adults impressions along these different dimensions of social power.

Across multiple studies, the participants' ratings of the targets' projected status and leadership qualities were positively correlated with the real-world strength of each person. That is, people that were physically stronger were perceived as such, and were also interpreted as being better leaders and having greater upward mobility within the consultancy. The predictive relation between the real-world strength of each person and participants' ratings of projected status and leadership remained significant even after controlling for other positive attributes like attractiveness. This suggests that participants' attributions were relatively strength-specific, rather than the result of a general positive "halo effect" which might result from attending to apparent musculature. Correspondences between adults' attributions of strength and social status also appear in adults' attributions from inherent facial features. For example, adults fail to distinguish between two faces when the features of one face have been modeled over judgments of physical strength and the features of the other have been modeled over judgments of social dominance (Toscano et al., 2014; 2016).

Together, the above studies suggest that when adults search for people that are either physically or socially powerful, they tend to pick the same people. This suggests a high degree of similarity in adults' representations of people that are physically and socially powerful, however, this similarity may be limited to instances in which adults' impressions arise form others' inherent physical features. It is not clear whether nonverbal behaviors similarly influence adults' judgments; perhaps

because attributions from these cues reflect considerations for how social rank influences the freedom with which two people can express emotions.

Speculation about the origins of adults' perceptions of power

Differences in power arise from many sources. People may show deference and comply with the wishes of others who are physically formidable. Doing otherwise could mean incurring severe physical consequences. People may also show deference and comply with the wishes of others because who occupy a formalized position of authority. Doing otherwise could mean incurring severe professional consequences. Though being "formidable" and being "in charge" describes unique sources of social influence, adults are able to label instances of relative physical strength based on others' appearance and relative social rank based on others' appearance and postural expressions. In addition, adults use information about one dimension of power to make inferences about another. For example, adults attribute relative social rank to unfamiliar people based on apparent differences in their formidability. While this strategy has clear adaptive benefits, there is a significant body of work suggesting that this strategy is unlikely to lead to accurate inferences about social structure.

In human societies, social hierarchies can be organized along nearly any valued dimension (Magee & Galinsky, 2008), however, adults place significant value on person-specific characteristics like competence, intelligence, and possessing exceptional skills relative to others. People that signal these qualities are more likely to obtain status and influence in group-settings (Anderson & Kilduff, 2009; Barkow et al., 1975; Chen et al., 2014; Hardy & Van Vugt, 2006; Henrich & Gil-White, 2001;

Kennedy et al., 2013; Van Vugt, 2006). Thus, while adults' initial impressions of formidability may influence their intuitions about a person's social rank, formidability has little relevance to formal rank acquisition in practice.

Where do correspondences between notions of formidability and formal rank come from? One extremely influential model of humans' rank acquisition draws heavily on evolutionary theory noting that coercive strategies of intimidation, force, and prowess in physical conflict (collectively referred to as dominance strategies) leads to successful rank acquisition in many nonhuman species including chimpanzees. Given our common ancestry with chimpanzees, it is likely that the processes of social organization at work in modern human society are continuous with the processes at work in other animals. Though the details of this process are obscure, the apparent divergence between the status conferring processes of other primates and humans depends in large part on a) evolved capacities for shared intentionality and b) selective pressure for the high-fidelity transmission of cultural information (Barkow et al., 1975; Henrich & Gil-White, 2001; Sterelny, 2012; Tomasello, 1999). As a consequence, humans slowly began to organize around leaders that facilitated dissemination of quality information – people recognized as skillful, knowledgeable, and who are predisposed to facilitate broader cooperation in group-contexts. In short, prestige-based strategies of rank acquisition are the norm in modern adult societies because of the continued cultural value of these traits.

Like most dichotomies, the dominance-prestige distinction fails to account for the full variety of ways in which people acquire social rank and influence. Indeed, the most influential of people are likely to exhibit some combination of these dominance

and prestige-based strategies (Chen et al., 2014; Hawley, 1999; 2007). However, the Dominance-Prestige model provides an evolutionarily plausible explanation of why the status conferring processes of modern humans differ from those of our closest primate ancestors. Namely, that selective pressures forced humans down and novel pathway of cognitive and cultural adaptation that explains uniquely human forms of social organization.

While the cultural value placed on prestige relevant traits insures that status is most often allocated to people that are competent rather than the coercive, seemingly unreliable inferences about social structure persist. But what is the medium of transmission from ancestral environments to today, particularly if social organization differs so greatly from these bygone environments? The answer to this question does not appear below. Rather, I point out two things. First, developmental psychologists have already begun the hard work of characterizing this transmission processes. Second, this work has focused on adjudicating between the merits of two competing, but by no means mutually exclusive, which provide an explanation for adults' tendencies to attribute greater social rank to formidable others. One of these explanations posits that infant's and children's earliest experiences of participating in and observing relational differences in power facilitate psychological correspondences between notions of various person-specific traits and notions of social rank.

Another explanation posits innate conceptual primitives of hierarchical relations. On this view, humans are born possessing innately specified relational models of social hierarchy, and the processes of hierarchical differentiation that were

prevalent in ancestral environments - i.e., dominance processes - have shaped these representations.

Hierarchical Differentiation in Young Children

Adults dislike and discourage dominant strategies of social ascendancy. The same is not true of young children. Early ethological studies show that hierarchical differentiation is common amongst young children, and the hierarchies that children form are heavily influenced by individual differences in the tendency to initiate physical conflicts with other (Edelman, 1973; Edelman & Omark, 1973; Hanfmann, 1935; Omark, Fiedler, & Marvin, 1976; Sluckin, 1980; Strayer & Strayer, 1976, 1980; Strayer, Strayer, & Chapeskie, 1980; Weisfeld, Omark, & Cronin, 1980). Children who initiate the most conflicts are both liked and closely attended to by their peers, and they have influence over the decision-making and play activities of others.

Children's behaviors do not just eventuate in hierarchical relations of attention and control; children appear to represent these relations. By 4, there is widespread agreement in children's linear rankings of both the "toughness" and "likeability" of their peers as well as high correlations between these orderings (Omark, 1980). Children consistently apply these labels to children who are more likely to initiate conflicts with others, suggesting that children are roundly attending to agonistic behaviors and generally admire those who enact them.

The above studies describe a social environment in which children might both initially acquire power-relevant concepts like "tough" and "social rank" as well as form psychological correspondences between these concepts. For example, children might initially acquire the concept of "tough" by generalizing across the agonistic

behaviors of their peers, and children might initially acquire the concept of "social rank" by noting the social influence of a minority of their peers. Psychological correspondences between toughness and rank may emerge as children become more familiar with the causal role that these agonistic behaviors play in establishing peer relations. Although children and adults quickly begin to discourage dominant strategies of social ascendancy (Cillesen & Mayeaux, 2004; Hawley, 1999; Pellegrini et al., 2011) adults' continued tendency to attribute greater social power to people that appear formidable might reflect continuity in this particular conceptual organization. However, there is no direct evidence that children make inferences about formidability or strength from a person's appearance or that they reason from a person's physical appearance to their likely social influence.

Children's Sensitivity to Relative Social Power

To date, almost all studies of children's ability to attribute relative social power to unfamiliar people has concerned their interpretation of others' overt behaviors. Between 3- and 5-years-of age, children consistently attribute greater social power (i.e., being "in charge" or "the boss") to people who acquire more resources than others, who have greater decision-making power such as giving or denying permission to others, and who are selectively imitated by others (Bernard et al., 2016; Charafeddine et al., 2014; Gülgöz & Gelman, 2016; Over & Carpenter, 2014). In each of these studies, children were presented with scenarios that had many structural similarities to those encountered with peers (e.g., conflicts over desired resources). The study by Over & Carpenter (2016) is a marked exception where 5-

year-olds, but not younger, children interpreted a person who was selectively imitated as being "in charge" relative to someone that was not imitated.

Together these studies suggest that young children's conceptions of relative social power are abstract enough to be applied to unfamiliar people when their behaviors give fairly direct evidence about their social roles. However, there is only a single study that children (like adults) are also sensitive to more subtle indications of a person's power such as their nonverbal postural expressions. By 4, children (like adults) are more likely to identify people with broad, expansive posture as being "in charge" relative to people that exhibit constricted, diminutive posture (Brey & Shutts, 2014). Children are sensitive to this cue in static images of people engaged in both familiar (i.e., a face-to-face interactions) and unfamiliar contexts (i.e., a business meeting). This finding establishes that children are sensitive to how people relate to one another in situations about which they are unlikely to have previous experiences and in the absence of behaviors which give direct evidence about two people's social roles. This study also benefits from giving a clear definition of being "in charge" to participants – i.e., the person who makes the rules and tells others what to do. Unlike previous studies where being "in charge" or the "boss" is undefined, this study gives straightforward evidence that children reason from nonverbal behaviors to others' social roles and authority. But this finding also opens many important questions about their capacity to do so. For example, what person-specific inferences does relative posture support? Children might attend to differences in posture and interpret these cues as different expressions of two people's current emotional states. Alternatively, children might attend to the size-enhancing aspect of posture and interpret these as

indicative about two people's inherent traits (e.g., age) or capabilities (e.g., strength). Future work can narrow these possibilities by assessing if children make a variety of power-relevant attributions on the basis of relative postures. For example, if children's inferences from posture to social power are mediated by person-specific attributions of people's capabilities, then they should be more willing to attribute relative strength and social power to people exhibiting expansive postures.

In summary, children are sensitive to instances of relative social power between unfamiliar people, however most studies have assessed children's reasoning about others overt behaviors. Thus, it is not clear at what age children show an adult-like tendency to infer a person's social power on the basis of either their inherent physical appearance, however, children infer relative social power from differences in postural expressions emerge by 4 but it is not clear why posture supports these attributions. Future research can begin to answer this question by investigating the variety of power-relevant attributions that children make toward people enacting different postures.

Children's Sensitivity to Relative Strength

Young children are sensitive to instances in which two people differ in terms of their person specific traits and capabilities, including instances of relative physical strength. By at least 4, when children see that a person is unable to lift a heavy item, they will recommend for that person to recruit the help of the stronger of two individuals (Paulus & Moore, 2011). In this study, the relative strength of two characters was demonstrated in two ways. First, children were introduced to two action figures that differed in terms of their apparent musculature. Second, one

character (the more muscular character) commented on his strength by mentioning that they had just won a strong man competition, while the made an irrelevant comments saying that they were having a nice day. Later, when the protagonist struggled to lift a heavy object, children were asked which of the two characters the protagonist should ask for help. Children tended to endorse the more muscular character. However, it is not clear whether children endorsed this character because of the differences in their musculature, their comments about their abilities, or some combination of these twos sources of information.

This same interpretive challenge occurs for other studies. For example, 6-year-olds expect that the stronger of two characters is more likely to win a conflict over a contested resource when differences in strength are explicitly labeled for them (this person is strong and this one is not: (Pietraszewski & Shaw, 2015) or when two characters' differential ability to lift a heavy object is accompanied by explicit claims about their capabilities - e.g., "I am/am not good at that" or "He can/can not lift that": (Fusaro, Corriveau, & Harris, 2011; Hermes, Behne, & Rakoczy, 2015; Hermes, Behne, Bich, Thielert, & Rakoczy, 2017; Pietraszewski & Shaw, 2015). Thus, while children are capable of labeling and reasoning about instances of relative physical strength, it is not clear whether (like adults) children spontaneously infer these differences on the basis of a person's appearance, nor is there any evidence that children's initial impressions of strength lead to broader social inferences such as a person's social power and authority as they do in adults.

There are only two demonstrations that young children infer relative strength or formidability on the basis of differences in two people's inherent physical features.

The first concerns children's reasoning about the overall size of two characters. Lourenco, Bonny, & Schwartz (2016), presented preschool-aged children with displays of two groups of agents (square-shaped characters with eyes). The experimenter explained that the groups were going to compete for a desired item (e.g., access to a game and cookies) and children were told to indicate which group they thought would "win" the item. In some trials the two groups that were competing differed in their inherent physical size (e.g., the agents in one group were twice as large as the agent in the other), and in other trials, the two groups differed in their numerical size (e.g., 2 vs. 4 agents). Subsequent analyses revealed that 3-year-olds generally expected the larger group to win the contested item. This expectation held when the groups differed in either physical or numerical size, suggesting that children can reason about both person-specific differences to anticipate the outcomes of conflict, as well as reason about group-level information. Interestingly, children seem to try and attend to both person- and group-level information simultaneously. As the groups size got larger but physical size was in conflict (e.g., 5 large agents vs. 10 small agents) neither 3-year-olds nor adults had consistent expectations about who would win the item. This suggests that children and adults try to integrate over different sources of power-relevant information simultaneously. However, because children were asked to reason about the appearance of square-shaped agents whose overall size was exaggerated, it is not clear form this study whether they are sensitive to differences in inherent appearance as it relates to people that they might encounter or observe in their daily lives.

Though there is a single study demonstrating this ability. Children between 3 and 10 years viewed paired images of faces (bodies were not visible) that differed in terms of their inherent facial structure and adults' impressions of "dominance" (Cogsdill et al., 2014). By 4, children consistently attributed greater physical strength to more mature, masculinized faces, and their tendency to do so was similar to adults (Cogsdill et al., 2014). This sensitivity to relative strength on the basis of facial structure suggests that children's conceptions of people that are strong contain information about appearance that is closely aligned with adults. However, it is not clear whether differences in facial structure elicit a variety of power-relevant attributions in children as this cue does for adults.

In sum, children's impressions of relative strength and social power have, so far, been studied in isolation. While these studies provide initial evidence that children draw on similar cues as adults to make power-relevant attributions, they do not establish at what age potentially distinct notions of power become integrated in children's evaluations as they are for adults. As discussed earlier, children's early interactions with peers might support adult-like inferences from one dimension of power to another. However, more work is needed to determine at what age these distinct notions of power become integrated humans' initial impressions of others, particularly in response to others' inherent appearance and nonverbal behaviors.

Returning to the discussion of emergence, recent research cast serious doubt on whether humans acquire many power-relevant concepts in early childhood. Controlled studies with preverbal infants demonstrate that they are sensitive to instances of relative power in contexts that are structurally similar to those that

children and adults are sensitive to. These studies suggest that children's capacities are supported by conceptual achievements obtained at younger ages than previously suspected.

Infants' Perceptions of Power

Within the first year of life, human infants evaluate others based on their positive or negative intentions towards others. For example, infants show a marked preference for characters that "help" others to achieve instrument goals like retrieving a toy or ascending a hill, and actively avoid characters that "hinder" people in these same endeavors (Hamlin, 2013; 2015; Hamlin, Wynn, & Bloom, 2007). While most discussion of these results have revolved around the nature of the attributions that children are making toward helpers and hinders in these scenarios, it has not been until recently, that researchers have focused on infants' representations of the underlying conflict inherent in acts of hindering. When conflicts arise, children and adults reason about how person-specific and group-level differences in power might influence their outcome, but researchers have only begun to investigate infants' expectations about similar scenarios.

Like studies with older children, studies investigating infants' perceptions of differences in power have largely concerned their ability to make power-relevant inferences on the basis of others' overt behaviors. For example, Mascaro & Csibra (2012, 2014) presented infants with videos of animated agents engaged in various conflicts to assess whether these young participants were capable of forming representations of the relative dominance between characters. Across multiple studies, they demonstrated that 15-month-olds inferred that an agent who

outcompetes another for an attractive item would continue to outcompete the same agent in a different context. This finding establishes that even preverbal infants form relatively stable representations about asymmetries in control two agents. Importantly, once an asymmetry between two agents has been established, they will expect that same asymmetry to hold in contexts outside of those in which the asymmetry was initially established. However, these studies also revealed important limitations of infants' ability to represent the relative dominance relations between multiple agents. In Mascaro & Csibra (2014), 15-month-olds failed to generate expectations about dominance relations between unfamiliar agents, even when they could have formed these expectations via "simple" calculations of transitive inference. However future studies have shown that infants are capable of forming representations of linear dominance relations when they have the opportunity to view each of the dyadic interactions that establish the hierarchy (Mascaro & Csibra, 2014), and can form expectations for novel interactions when all of the agents are visible when the relevant interactions occur (Gazes & Hampton, 2015).

Subsequent research has built on these findings, demonstrating that preverbal infants form expectations about relative dominance in ways that are more similar to older children and adults. For example, the first study to investigate infants' sensitivity to differences in power explored infants' expectations for conflict outcomes when two agents differed in their overall size (Thomsen et al., 2011). In this study, infants between 8 and 16 months were familiarized to two different videos of agents (one was twice as large as the other) crossing a platform. One agent crossed the platform from left to right, and the other crossed the platform from right to left.

These videos demonstrated to infants that each character (when alone) would cross the entire platform. After this familiarization, infants saw a video in which the two agents now appeared on the platform continuing on their familiarized paths toward each other. When the agents met in the middle, they gently collided with each other and then made repeated contact three times. This video intended to demonstrate that neither agent could complete their goal of crossing the platform in the continued presence of the other. Following this demonstration of conflict, infants saw two videos that displayed different possible outcomes of this conflict. In the LIKELY outcome, the smaller of the two agents leaned forward (as if bowing) and moved out of the larger agent's path, ostensibly conceding the path to the larger agent. In the UNLIKELY outcome, the larger of the two agents performed these behaviors, ostensibly conceding the path to the smaller agent. By 10 months, but not younger, infants showed a marked increase of attention toward videos demonstrating the UNLIKELY outcome relative to the LIKELY one. This finding (in addition to a variety of control conditions) provided the first evidence that infants can utilize information about relative size to form expectations for how potential conflicts will be settled.

More recent work has shown that even younger 6-month-olds expect that conflicts over desired resources will be settled in favor of the numerically larger of two groups (Pun et al., 2016). Ongoing work with infants seeks to understand how infants' earliest apprehensions of relative power factor in to their broader social considerations. One recent study shows that despite infants' expectations that resources should be distributed fairly amongst unfamiliar people (Geraci & Surian,

2011; Schmidt & Sommerville, 2011), this expectation dissolves in the presence of information about dominance and is replaced by expectation for distributions that favor the more dominant of two individuals (Enright, Gweon, & Sommerville, 2017).

Future Directions

Studying the earliest instances of humans' perceptions of relative dominance, the cues that they utilize to apprehend these differences, their expectations for social outcomes that involve asymmetries in power, and how these various evaluations interact across development represents a new frontier in developmental social psychology. By exploring the representational capacities and social evaluations of infants and young children, we can actively test hypotheses about the extent to which the psychological processes supporting humans' perceptions of dominance are continuous with those of other primate species, as well as gain insight into uniquely human forms of social organization. For example, to date, infants' earliest sensitivities to relative power have largely been formed on the basis of overtly agonistic and controlling behaviors or physical cues that predict successful outcomes in physical conflicts. Do infants prefer these more physically dominant individuals and do these social preferences explain the interaction patterns and social preferences exhibited by young children with their peers? Of particular import will be to uncover the origins of the underlying conceptual structure supporting adults' initial impressions of other people. Despite actively disliking dominant strategies of social ascendancy, adults still show a bias to initially interpret more formidable people as better leaders. What experiences (if any) foster these particular conceptual relations? Are these initial biases robust in the face of more legitimate information

about leadership capabilities? In a word, if we are evolutionarily predisposed to confer greater status and power to those whose capabilities that are most relevant to a bygone era, then we should investigate and accept this fact head on. In this way, we might eventually develop methods to overturn these initial biases to confer status on those who might successfully meet the challenges of the world today.

Chapter 2: Children's Developing Judgments About the Physical Manifestations of Power

"Power" refers to a person's potential to control and influence others (Emerson, 1962; French, 1956; Magee & Galinsky, 2008). Aligning oneself with powerful people can be advantageous, earning physical protection and social privilege. Furthermore, ignoring the desires of a powerful person can be dangerous, risking physical reprisal, social sanction, or other negative consequences. To ensure adaptive outcomes, people must be able to recognize who is powerful, anticipate what powerful people want, and respond strategically to their behavior.

Navigating real-world power dynamics is far from straightforward. Consider the challenges of one's first day in a workplace, on the prison yard, or at a new school. Who holds power? When entering new social contexts, information that clearly reveals the relative power of specific individuals may be sparse. Diagnostic third-party interactions (e.g., seeing one person tell another what to do) may not occur, controlled resources (a privilege of the powerful) may be kept out of sight, and conventional signifiers (e.g., special clothing) may require local cultural knowledge to appreciate their meaning. Given these constraints, observers should be highly motivated to seek evidence about power from information that is more reliably available. One such source of information is a person's physical appearance, which can reflect both physical characteristics like strength and more subjective attributes like confidence.

An additional challenge of navigating power dynamics is that humans derive power from multiple sources. Those with superior physical capabilities, such as brute

strength, may assert control through physical force or intimidation. Others may hold powerful social roles, such as being a boss, that grant a more normative basis for their authority. The relation between physical strength and normative authority is complex: Some individuals possess one but not the other, while others may draw power from both of these sources. Recognizing the basis of a person's power and its relevance to a particular context (e.g., in an alley versus a boardroom) is critical for making decisions about how to best monitor and respond to them.

Here we examine children's developing abilities to meet both of the challenges identified above: determining who is powerful from limited social information like physical appearance and appreciating that power can be based on both physical ability and normative social roles. As reviewed below, research with adults has begun to reveal the conceptual structure upon which judgments about power are made. Yet key questions remain regarding the interrelations between different perceptual cues to power and their various interpretations, as well as the developmental mechanisms that support the emergence of these links. For the present investigation, we focus on children's developing judgments regarding two cues in particular: facial structure and body posture. Each of these cues is available to observers even when a person is not socially engaged with others, and each one is the basis for a range of power-relevant judgments made by adults.

Adults' Attributions of Power

When adults encounter new people, they infer power from multiple aspects of appearance. They view people with more mature or masculine facial structure (e.g., a pronounced brow or jawline) as both physically stronger (Holzleitner & Perrett, 2016;

Toscano, Schubert, & Sell, 2014; Toscano, Schubert, Dotsch, Falvello, & Todorov, 2016) and more socially dominant (Lukaszewski, Simmons, Anderson, & Roney, 2016; Oosterhof & Todorov, 2008; Toscano et al., 2016). Adults also recognize that body posture both reflects a person's current feelings of power (Tracy & Matsumoto, 2008; Tracy & Robins, 2004; 2008) and communicates one's assumed status to others (e.g. a person may assert authority through expansive poses; Brey & Shutts, 2015; Burgoon, Buller, Hale, & Turck, 1984; Holland, Wolf, Looser, & Cuddy, 2017; Koski, Xie, & Olson, 2015).

Although adults understand that physical strength and authority are different things, their attributions reveal similar thinking about the physical manifestation of these two forms of power. For example, faces that adults describe as socially "dominant" are similar to those they describe as physically "strong" (Toscano et al., 2016). Further, although no research has examined whether expansive postures make bodies appear stronger, there is evidence for links between related representations: adults view people with a muscular physique as both strong and likely to hold authority and influence over others (Lukaszewski et al., 2016). Results like these reveal that there is overlap between the concepts of strength and authority evoked by certain facial structures and body poses.

A striking signature of adults' power intuitions is that they are highly consistent across observers (Lukaszewski et al., 2016; Oosterhof & Todorov, 2008; Sell et al., 2009). For example, a person judged to be either strong or "in charge" by one person will likely be judged similarly by others. In fact, consensus about the physical features that signal power is observed cross-culturally, and interrater

agreement about who appears strong or "in charge" remains high even when people judge the appearance of members of other cultures (Lukaszewski et al., 2016; Oosterhof & Todorov, 2008; Sell et al., 2009). This interpersonal agreement is easiest to explain for intuitions that are accurate reflections of the world, such as attributions of physical strength from certain body types (Sell et al., 2009). Yet other common intuitions about power, such as viewing certain facial structures as indicating leadership (Van Vugt & Grabo, 2015) or social dominance (Oosterhof & Todorov, 2008), are unlikely to reflect the statistical realities of the world (Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015). For example, it is not always the case that person with a masculine facial structure holds a position of authority. Thus, although adults agree that people with certain physical appearances are likely to be powerful, these shared intuitions can be poor social guides: they may see power where it does not exist, and they may underestimate the power of people with more unassuming appearances.

The pervasiveness of adults' highly consistent yet often inaccurate judgments about power is puzzling. Several explanations have been offered. One position is that present-day judgments are based on innate associations that had predictive value in our evolutionary past (Lukaszewski et al., 2016; Sell et al., 2009; Zebrowitz, 2017). This account has been offered for both the attributions of leadership qualities to particular facial structures (Van Vugt & Grabo, 2015) and the conceptual link between formidability and authority (Lukaszewski et al., 2016). A second position is that highly consistent power judgments are overgeneralizations from two other products of natural selection: representations of features involved in emotional

expressions, and a strong motivation to determine the dominance of conspecifics. For example, because immutable facial features like a pronounced brow resemble temporary expressive behaviors like a furrowed brow, people who possess these features may initially be interpreted as either aggressive or socially dominant. Although this position has mainly been offered to explain judgments of facial structure (Oosterhof & Todorov, 2008), in principle it should apply to judgments of body posture as well. Lastly, a third position rejects proposals for evolutionary specializations entirely, suggesting that associations between physical appearance and traits like dominance are cultural constructions learned during development (Over & Cook, 2017).

These three accounts make starkly different claims about the relative contributions of innate foundations and early experience to adults' power judgments. As we articulate in the next section, developmental investigations have the potential to provide insight into these considerations, thereby helping to illuminate the basis for adults' consistent intuitions.

Developmental Origins of Power Attributions

Young children are sensitive to the same aspects of facial structure and body posture that adults judge as powerful. Most notably, preschoolers reason that a person with mature, masculine facial features is "stronger" than someone who lacks these features (Cogsdill, Todorov, Spelke, & Banaji, 2014) and that a person with broad, expansive posture is "in charge" relative to someone exhibiting diminutive, restrictive posture (Brey & Shutts, 2015; Charafeddine et al., 2014). These attributions reveal that, like adults, children see correspondences between certain aspects of appearance

and different forms of power. Nevertheless, little else is known about how children's sensitivity to these cues arises and what other forms of power children attribute to them. Consequently, it is difficult to characterize the conceptual framework supporting children's judgments.

One body of open questions concerns children's representations of how powerful people appear. First, when do children first become sensitive to the individual aspects of appearance that adults view as powerful? Cogsdill and colleagues (2014) observed sensitivity to power-relevant dimensions of facial structure (i.e., mature and masculine features) in a collection of 3- and 4-year-old children but did not report analyses that explored possible developmental changes within this developmental period. A more recent study with much younger children found that 7-month-olds do not distinguish between faces with more or less masculine facial features (Jessen & Grossmann, 2016). It is thus unclear when children's sensitivities to these aspects of facial structure first emerge, highlighting the need to conduct more thorough investigations of children's sensitivity in early childhood. Other ambiguities arise with respect to body posture. Charafeddine et al. (2014) have shown that 3-year-olds associate expansive and restrictive postures with social dominance and subordination, respectively. When these cues are presented explicitly as part of an interpersonal conflict, 3-year-olds will anticipate that a person with expansive posture is more likely to impose their will on someone exhibiting restrictive posture. However, Brey & Shutts (2015) found that it is not until the 5th birthday that children use similar postural information to judge the relative authority of two people when there is no overt conflict between them. Thus, it is unclear if 3- to

4-year-olds spontaneously infer power differences from an individual's posture or whether an expectation that power differences are present (e.g., from Charafeddine and colleagues' stories) scaffolds younger children's interpretation of postural differences.

Second, do children represent connections between different appearance-based sources of information about a person's power? By analogy, infants see correspondences between emotions expressed in faces and postures (Grossmann, 2010; Hock et al., 2017), and adults use facial and postural information together to infer a person's emotional state (de Gelder, de Borst, & Watson, 2014; Hassin, Aviezer, & Bentin, 2013). A similar integration of facial and postural information may occur for power-related representations, either because it offers functional advantages or simply as a generalization from emotion representations. Yet no studies have investigated whether children or adults see correspondences between powerful faces and bodies.

Another body of open questions concerns the range of meanings that children associate with different sources of evidence about an individual's power. When considering behavioral evidence, 3- to 4-year-old children expect people to have more normative authority when they also have more resources, achieve more goals, and exert greater social influence than others (Charafeddine et al., 2014; Gülgöz & Gelman, 2016). Yet previous investigations of children's judgments from visual appearance have only assessed attributions of a single notion of power from a single aspect of appearance (i.e., just strength from facial structure; just authority from posture). Given the interrelations of cues and meanings found in adults' judgments,

children may be developing a more complicated understanding of power than previous approaches have revealed.

Knowing what meanings children ascribe to different cues is an essential step in describing the conceptual framework underlying their understanding of power. It may be that different sources of information, such as faces and postures, each initially engage different notions of social and physical power, which only later become integrated. Or, it may be that children's sensitivities to powerful faces and postures are initially linked to the same notion of power. That notion itself might be a theory of power that already draws connections between physical strength and more normative authority. Alternatively, early notions of power may derive entirely from representations of physical formidability, and only later incorporate consensual norms of authority.

Developmental investigations describing children's intuitions about the physical manifestations of power can provide insight into the origins of adults' consistent judgments. An improved timeline of children's emerging sensitivities to power-relevant aspects of appearance can help to elucidate whether humans' representations of powerful people are grounded in either evolved or acquired capacities. Further, assessing children's reasoning about different forms of power can reveal whether they see the same conceptual distinctions that adults do. In the present study, we investigated children's developing representations of appearance and power together, to better understand how these different representational capacities become integrated, thereby increasing the apparent social relevance of other people's physical appearance.

The Present Research

To investigate these issues, we examined both adults' and children's intuitions about how different notions of power (i.e., "strength" and "in charge") describe variation in faces and postures. Experiment 1, conducted with adult participants, served multiple purposes. The main goal was to characterize the full pattern of adults' judgments before investigating the same patterns in children. Although prior work has assessed adults' intuitions about a subset of these cue and inference combinations (e.g., physical strength and normative authority from faces (Lukaszewski et al., 2016; Oosterhof & Todorov, 2008; Sell et al., 2009), one combination was novel (i.e., physical strength from postures). Additionally, as no research to our knowledge has asked about all combinations together (e.g., physical strength and normative authority from both faces and postures), the present study illuminates the relative strengths of these inferences.

Experiments 2 and 3 took two different approaches to assessing young children's intuitions about the physical manifestation of power. First, in a task that closely resembled the one that adults completed, we asked children to produce judgments about physical strength and normative authority from variation in faces and postures. Second, we designed a task to assess the extent to which children view powerful faces and bodies as "going together". We conducted these studies with children from 3 through 5 years of age, as previous research has revealed developmental changes in children's sensitivities to power-relevant variation in faces and postures during this period (Brey & Shutts, 2015; Charafeddine et al., 2014; Cogsdill et al., 2014).

Experiment 1

Experiment 1 assessed the separate influences of facial structure and body posture on adults' attributions of strength and authority.

Method

Participants. Thirty-two adult undergraduate students with normal or corrected-to-normal vision (16 females; M_{age} = 20.04 years, SD = 1.57 years) participated online for course credit. Four additional students who did not complete the study were excluded. No complete responses were excluded from analyses.

Materials. Participants viewed paired images of two people, side-by-side and facing forward (i.e., not interacting with one another). Half of these displays showed two faces differing in their inherent structure (bodies were not visible). The other half showed two bodies differing in their outward postural expressions (faces were not visible). Figure 1 shows example displays and the entire stimulus set is available at OSF [link blinded for anonymity]. Characters were aligned so that neither seemed taller than the other. High and low power faces occupied an approximately 600x400 pixel region of the display. High and low power bodies occupied an approximately 730x490 and 730x270 pixel region, respectively.

Face stimuli were drawn from a larger database of 175 male, computer-generated faces (Oosterhoff & Todorov, 2008). Each face was derived from a computational model capturing the aspects of facial structure that covary with adults' judgments of a face's "dominance". Faces high in dominance have mature, masculine features (e.g., pronounced brow and jawline) while faces low in dominance have less mature, less masculine features. Adults' impressions of these faces have

been extensively validated in many studies of dominance perception (Cogsdill et al., 2014; Oosterhoff & Todorov, 2008; Toscano et al., 2014; Toscano et al., 2016).

Body stimuli were drawn from a larger set of 132 male, computer-generated characters created by the authors using Poser version 10. The body pose of each character was manipulated based on prior research demonstrating that adults view people holding expansive postures as "powerful" and restrictive postures as "less powerful" (Brey & Shutts, 2015; Burgoon, Johnson, & Koch, 1998; Holland et al., 2017).

We planned to compare participants' inferences across faces and bodies, as well as to compare different inferences within each stimulus type. We thus conducted an initial norming study to ensure that adults' perceptions of dominance for the final set of stimuli were matched, both across and within faces and bodies (see SI for details; no adults who participated in the norming study participated in Experiment 1). Figure 2 shows that the final stimulus set had excellent properties.

Procedure and design. The following procedure was approved by the Institutional Review Board of [blinded title and protocol #]. On each of 20 trials, participants indicated whether the more powerful character was on the left or right. Trials proceeded in four blocks (5 trials each). Each block presented the same cue (i.e., faces or postures) and requested the same attribution (i.e., strength or authority) across trials, reflecting a 2 x 2 within-subject design. Before each block, we instructed participants to select the person they thought was "stronger" or "in charge", and we

provided a clear definition of these terms: “A person who is strong is someone who can lift and move really heavy things” or “A person who is in charge gets to make all the rules and gets to tell others what to do”.

The initial cue and attribution types were counterbalanced across participants. Whereas cue type alternated between blocks, the attribution type was the same for the first two blocks and then switched. To assign stimuli to blocks, the 10 face and 10 body pairs were divided into two sets (5 face and 5 body pairs each), whose presentation order was counterbalanced across participants. Within blocks, the presentation order of images was determined by a random number generator and fixed for all participants. Across both cues and attributions, the more powerful character appeared with equal frequency on the left and right.

Coding and scoring. All analyzed participants responded on all trials. These responses were coded for consistency with the answers suggested by our prior norming study (i.e. selecting the person with a mature, masculine face or the person exhibiting broad, expansive posture as the more powerful character). For each of the four blocks, scores were calculated reflecting the proportion of trials in which the anticipated response was given.

Results

The original data used to conduct the following analyses are available through OSF [link blinded for anonymity]. Preliminary analyses involving participant gender and the counterbalancing factors appear in the SI. As there were no main effects of gender or any of the counterbalancing factors, these factors were omitted from the focal analyses below.

Figure 3 presents average responses for each combination of Attribution and Cue types. A repeated-measures ANOVA assessed the influence of these factors on participants' judgments. One-sample t-tests on each trial type assessed whether participants responded in the anticipated manner at rates exceeding chance (chance = 0.50). There were main effects of both Attribution, $F(1, 31) = 6.66$, $p = .015$, $\eta_p^2 = .18$, and Cue, $F(1, 31) = 7.86$ $p = .009$, $\eta_p^2 = .20$, as well as a significant interaction between these factors, $F(1, 31) = 24.22$, $p < .001$, $\eta_p^2 = .44$. Participants attributed both strength and authority (i.e., being "in charge") from facial structure in the predicted manner ($M_{\text{strength}} = .90$, $SD = .21$, $t(31) = 10.80$, $p < .001$, $d_z = 1.91$; $M_{\text{authority}} = .83$, $SD = .30$, $t(31) = 6.14$, $p < .001$, $d_z = 1.09$), but they only attributed authority from body posture ($M_{\text{strength}} = .56$, $SD = .35$, $t(31) = .90$, $p = .376$, $d_z = .16$; $M_{\text{authority}} = .89$, $SD = .23$, $t(31) = 9.43$, $p < .001$, $d_z = 1.67$). Judgments about relative strength from differences in body posture were less consistent than judgments about relative strength from facial structure, $t(31) = 5.06$, $p < .001$, $d_z = .89$, relative authority from body posture, $t(31) = 4.78$, $p < .001$, $d_z = .85$, and relative authority from facial structure, $t(31) = 3.05$, $p = .005$, $d_z = .54$.

Discussion

Our findings converge with those from previous demonstrations of adults' attributions from faces. The same mature, masculine facial features that give rise to impressions of physical strength also support impressions of authority (Toscano et al., 2016). Adults' attributions from faces thus suggest conceptual relations between these distinct notions of power. However, participants' impressions of people differing in their outward postural expressions also provide novel insight into the limits of these

links: Adults saw people with broad, expansive posture as holding more authority, but did not consistently view these same people as stronger. The results from Experiment 1 provide a baseline for evaluating the development of children's intuitions about the power of those whom they encounter.

Experiment 2

Experiment 2 investigated developments in young children's representations of powerful people in two different ways. First, children produced judgments about the relative power of different characters, in a child-friendly version of the task that adults performed in Experiment 1 ("attribution task"). Next, the same children completed a task probing whether they thought powerful faces and bodies "go together" ("matching task").

Method

Participants. Ninety-six 3- to 5-year-old children participated in the study, divided equally across three age groups (3-year-olds: M_{age} = 3.57 years, SD = .31; 4-year-olds: M_{age} = 4.55 years, SD = .27; and 5-year-olds: M_{age} = 5.50 years, SD = .29). Equal numbers of boys and girls were tested in each group. Participants were typically developing children exposed predominately to English (≥70%), recruited from a university database of families near [location blinded] who expressed interest in participating in developmental studies. Caregivers identified their children as primarily White (62.1%), Black/African American (15.8%), or Asian (11.6%). The remaining participants were a roughly even distribution of children identified as either Native American, Hispanic, or "Other". The modal income for families was

greater than $100,000 annually. Children were tested individually in a university research lab and received a small toy for their participation.

Eight additional children (four 3-year-olds and one 4-year-old) were tested but excluded from analyses because they failed to complete every trial of the attribution task. Another 4-year-old and two 5-year-olds were excluded because of a technical error that disrupted video recording of their responses.

Materials and procedure. All children participated in the attribution task first and the matching task second. The procedures of both tasks were approved by the Institutional Review Board of [blinded title and protocol #].

Attribution task. Display images were identical to those used in Experiment 1. Each child viewed the displays on a 23" monitor (1920 x 1080 pixels) at a distance of approximately 55 cm. The monitor was on a child-sized table. The experimenter sat slightly behind and to the left of the child; the experimenter was therefore out of the child's line of sight during test trials. The experimenter controlled the experimental display from a wireless mouse operated in their lap.

The task began with a brief practice session (3 trials) to accustom children to the experimenter's verbal instructions and to help them feel comfortable pointing at the screen. On each practice trial, children saw two circles (one yellow, one purple) and were asked to point to the purple circle. All children responded perfectly.

Next, the experimenter explained that they would now view images of people. Children were told to look at each person carefully and then point to the person who was either "stronger" or "in charge". Only one term was used prior to each block. Children heard the same definitions of these terms that adults read in Experiment 1.

All children confirmed that they comprehended these definitions the first time they were provided and the experimenter repeated the relevant definition before each block.

On each trial, a fixation cross was visible while the experimenter provided instructions, “Look at both people carefully, and point to the person who’s stronger/in charge”. The experiment made sure that the child was looking at the fixation cross before revealing the test display and did not provide feedback on the child’s selections.

***Matching task*.** Children were encouraged to place images of individual faces and bodies together. The face and body images were the same stimuli used in the attribution task. The body images were presented in a flipbook with a single body on each page. Laminated cut-outs of individual faces could be affixed to the bodies by joining small strips of Velcro, one located on the back of each face and the other above the shoulders of each body. The experimenter sat directly across from the child to administer the task.

The experimenter told the child a brief story – that the new game had a book with pictures of both faces and bodies but, earlier, all the faces fell off. The experimenter explained that they needed the child’s help putting the faces where they belong. Each trial began with the flipbook open to two blank pages. Next, the experimenter handed the child two face cut-outs, stacked one on top of the other. The more dominant face was always on top, and the experimenter prompted the child to look at both faces carefully. After the child had examined both images, the experimenter asked the child to place the faces side-by-side on the table (in whatever

order the child wished), so that both could be seen simultaneously. The experimenter then turned the page to reveal two headless bodies, one on each opposing page, and prompted the child to place the images "where they belong". The experimenter did not provide feedback on children's choices and did not make any suggestions for how faces and bodies could be aligned.

Design.

Attribution task. For each child age group, the experimental design was identical to the design employed in Experiment 1. Children participated in four 5-trial blocks, with each block focused on a single Attribution (i.e., "strength", "in charge") and Cue (i.e., face, body) type.

Matching task. The matching task consisted of 10 trials. On each trial, children saw the high and low power versions of a single face and body pair. The presentation order of the face and body pairs on each trial was determined by a random number generator and fixed for all participants. The body with expansive posture appeared with equal frequency on the left and right, in an ABBABBAABA fashion. Children were randomly assigned to one of two conditions that varied whether A referred to the left or right.

Coding and scoring.

Attribution task. On each trial, children responded by pointing to the character they thought was more powerful. As with Experiment 1, children's responses were coded for consistency with the direction expected by the "dominance" ratings of Experiment 1's norming study. For each of the four blocks, scores were

calculated reflecting the proportion of trials in which the anticipated response was given.

Matching task. On each trial, children affixed two cut-out images of faces to two images of bodies in a flipbook. Children's responses were coded from a video recording of the flipbook taken after the study was concluded. Children's choices on each trial were coded for consistency with the direction expected by the "dominance" ratings of Experiment 1's norming study. For each trial, scores were calculated reflecting the proportion of trials in which the anticipated response was given.

Two independent coders (the first author and a research assistant uninvolved in data collection) recorded the responses of all participants on each trial of both tasks from video recordings of each session. Their initial agreement was almost perfect (Attribution kappa = .98; Matching kappa = .98), and all discrepancies were resolved through discussion.

Results

The original data used to conduct the following analyses are available through OSF [link blinded for anonymity]. Preliminary analyses involving participant gender and the counterbalancing factors of both tasks appear in the SI. As there were no main effects of Gender or any of the counterbalancing factors in either task, these factors were omitted from the focal analyses below.

Attribution task. Figure 3 presents average responses for each combination of Attribution and Cue types for each age group. For the main analysis, a mixed ANOVA assessed the influence of Attribution and Cue types, across ages, on participants' judgments. There were main effects of Attribution type, $F(1, 93) =$

11.43, $p = .001$, $\eta_p^2 = .11$, Cue Type, $F(1, 93) = 4.12$, $p = .045$, $\eta_p^2 = .04$, and Age Group $F(2, 93) = 21.48$, $p < .001$, $\eta_p^2 = .32$. Children selected the anticipated character most consistently when attributing strength and when making judgments from variation in body posture. Overall, 3-year-olds were less consistent in their judgments than 4- and 5-year-olds, LSD post-hoc *p*s < .001, but 4- and 5-year-olds did not significantly differ from one another, $p = .119$.

To further understand developments in children's reasoning about powerful people, we examined each age group separately. In these planned analyses, we conducted one-sample t-tests for each question type comparing children's responses to chance (chance = 0.50), to determine whether or not children consistently answered in the manner predicted by adults' normed "dominance" ratings. Although we did not see a significant interaction involving Age Group in the main ANOVA described above, we also conducted additional planned analyses within each age group comparing children's attributions of strength and authority for each cue type, as well as analyses comparing children's performance on each trial type across ages; these are presented in the Supplemental Information.

Table 1 presents the results of the attribution task for each age group. Three-year-old children did not often respond in the predicted manner. They attributed strength to people with more expansive posture at rates exceeding chance, but they did not achieve similar performance when attributing strength to people with more dominant facial structure, nor did they attribute authority on the basis of either posture or facial structure. In contrast, 4-year-old children responded consistently on all four trial types. They attributed both strength and authority to people with

dominant faces and expansive postures. Five-year-old children also responded consistently on all four trial types. They attributed both strength and authority to people with dominant faces and expansive postures.

Matching task. Figure 4 displays children's performance on the matching task. An ANOVA assessed variation across the three age groups in children's matching responses, and found a significant effect of Age Group, $F(2, 93) = 18.85$, $p < .001$, $\eta_p^2 = .29$. LSD post-hoc tests indicated that 3-year-old children performed significantly worse than both 4- and 5-year-old children, p's < .001, whereas the two older groups did not differ from each other, $p = .254$. Three-year-old children matched powerful faces and bodies at rates marginally above chance, $M = .57$ $SD = .19$, $t(31) = 1.93$, $p = .063$, $d_z = .34$. Both 4- and 5-year-old children performed significantly above chance; 4 years: $M = .82$ $SD = .24$, $t(31) = 7.55$, $p < .001$, $d_z = 1.33$; 5 years: $M = .88$ $SD = .22$, $t(31) = 9.84$, $p < .001$, $d_z = 1.74$.

As detailed in Figure S3 in the Suppplemental Information, children at the youngest ages showed an approximately even distribution of matching task scores, suggesting that most did not have a strong intuition about how to complete the task. With increasing age, children more consistently paired dominant faces with expansive postures. There was no cluster of children at any age who matched masculine faces with bodies showing restrictive postures.

Associations between attribution and matching task performance. Finally, we examined the association at each age between children's performance on each trial type of the attribution task and their performance on the matching task. Table 1 displays these bivariate Pearson correlations. At 3 years, no correlations were

significant. At 4 years, there was a positive correlation between children's scores on the matching task and their attributions of strength from facial structure. At 5 years, children's scores on the matching task were correlated with their attributions of strength from facial structure and their attributions of authority from both facial structure and body posture.

Discussion

Experiment 2 provides a number of insights into the development of children's reasoning about powerful people and their appearances. The results from the attribution task suggest that, as children grow, their attributions of power increasingly incorporate the appearance-based cues examined here. Moreover, they come to view both facial structure and body posture as evidence for both strength and authority. The results from the matching task further suggest that, during this same developmental period, children increasingly bring information about facial structure and body posture together to form a single, coherent representation of how powerful people appear. Yet the developmental trajectory documented here is not simply one of increasingly adult-like intuitions: Unlike adults, even 5-year-old children confidently attributed strength from expansiveness in body posture.

One limitation of Experiment 2, however, is that children's participation in the attribution task may have influenced their performance on the subsequent matching task. Although the experimenter did not provide feedback on either, the attribution task may have increased the salience of the physical differences between high and low power characters or oriented children toward considering strength or authority

when encountering the same stimuli again. Experiment 3 addresses these considerations by testing a new group of participants on the matching task alone.

Experiment 3

Experiment 3 was a direct replication of the matching task from Experiment 2, conducted with a group of children who had not previously performed the attribution task. The experimenter made no comments about physical or social power, and this was children's first encounter with the face and body images. Consequently, matching powerful faces and bodies in the predicted manner could only be based on children's pre-existing expectations about how these two aspects of appearance should align.

Method

Participants. Ninety-six 3- to 5-year-old children participated in the study, divided equally across three age groups (3-year-olds, 13 females: M_{age} = 3.51 years, *SD* = .29; 4-year-olds, 13 females: M_{age} = 4.53 years, *SD* = .31; and 5-year-olds, 23 females: M_{age} = 5.52 years, *SD* = .27). Participants were typically developing children exposed predominately to English at home (≥70%), recruited from the same university database utilized in Experiment 2 (n = 44) and from a children's museum (n = 52) in [anonymized]. The demographics of both samples were similar. Caregivers identified their children as primarily White (67.7%), Black/African American (14.6%), or Asian (7.3%). The remaining participants were a roughly even distribution of children identified as either Native American, Hispanic, or "Other". The modal income for families was greater than $100,000 annually. Children who participated individually in a university research lab received a small toy for their

participation. Children who participated individually at the museum did not receive compensation.

Eight additional children were tested but excluded from analyses because of a video recording error (two 3-year-olds), failing to complete the study (one 4-year-old), parental interference (one 4-year-old), a parent-reported developmental delay (one 4-year-old), not meeting the language requirements of the study (two 5-year-olds), and because of an experimenter error (one 5-year-old).

Procedure, materials, and design. The procedure, materials, and design of Experiment 3 were identical to the matching task in Experiment 2 and were approved by the Institutional Review Board of [blinded title and protocol #]. Children's responses were coded and scored in the same manner and initial reliability between coders was nearly perfect (kappa = .98). Disagreements were resolved through discussion.

Results

The original data used to conduct the following analyses are available through OSF [link blinded for anonymity]. A preliminary analysis showed that participants' responses did not vary across participant gender or the left/right ordering of the powerful character. Thus, these factors were omitted from the focal analyses below.

Figure 4 displays children's performance in Experiment 3. Both 4- and 5-year-olds matched powerful faces and bodies at rates significantly above chance; 4 years: $M = .62$ $SD = .23$; $t(31) = 2.80$, $p = .009$, $d_z = .50$; 5 years: $M = .66$ $SD = .30$; $t(31) = 3.15$, $p = .004$, $d_z = .56$. Three-year-olds' responses did not exceed chance $M = .55$ $SD = .17$; $t(31) = 1.49$, $p = .146$, $d_z = .26$. Unlike Experiment 2, an ANOVA assessing the

influence of Age Group (3,4, or 5 years) on children's matching responses did not find a significant effect of Age $F(2, 93) = 1.94$, $p = .149$, $\eta_p^2 = .04$. An independent samples t-test confirmed that, overall, children in Experiment 2 ($M = .76$, $SD = .26$) performed better than children in Experiment 3 ($M = .61$, $SD = .24$): $t(190) = 4.12$, $p < .001$, $d_z = .60$.

Discussion

Experiment 3 largely confirmed the findings from Experiment 2. By age 4, children matched powerful faces with powerful bodies, demonstrating that they integrate information from different sources into a single representation of how powerful people appear. Children's ability to detect power-relevant correspondences between faces and postures does not depend on prior experiences with these specific stimuli or having been asked to label these images in similar ways. However, there was also some suggestion that scores on the matching task in Experiment 2 were influenced by children's recent history with the attribution task: without previous exposure to the stimuli, 3-year-old children did not even perform marginally above chance, and older children's performance was lower than in the previous experiment.

General Discussion

We examined children's and adults' abilities to meet two basic challenges of navigating the power structures of unfamiliar social environments: determining who is powerful from limited information (i.e., physical appearance), and recognizing that power can arise from many sources. Overall, children had increasingly detailed, integrated representations of powerful people. However, neither their sensitivities to powerful appearances nor their attributions of power developed uniformly across

different physical cues or notions of power. The developmental patterns observed here provide insight into the origins of our adult tendencies to judge power from appearance, as well as the conceptual structure upon which these intuitions are based.

Detecting Power from Appearance

We used multiple methods to assess children's sensitivity to the same physical cues that adults find powerful. First, we separately examined their attributions of power from variation in both facial structure and body posture. Second, we investigated whether representations of these two cues become linked during early development. This approach provided a detailed description of how representations of powerful appearances emerge during early childhood.

Children were sensitive to power-relevant aspects of facial structure by 4 years, choosing faces with more mature, masculine features as both "stronger" and "in charge". This finding converges with results from the youngest group tested in an earlier study (Cogsdill et al., 2014). However, that work pooled 3- and 4-year-old children together, potentially obscuring developmental changes during the early preschool years. The present study more precisely identifies the age at which a sensitivity to powerful faces emerges. Because 3-year-olds did not make consistent judgments about faces, it is likely that children become attuned to power-relevant aspects of facial structure between 3 and 4 years of age.

Sensitivity to power-relevant aspects of body posture emerged earlier: 3-year-old children indicated that people holding expansive postures were "stronger" than those with more restrictive postures. As this was the earliest age we tested, it is possible that even younger children may be sensitive to this postural information.

Moreover, the present findings also clarify what minimal information is necessary for children to infer power from posture. In prior research, 3-year-old children have used posture to determine power differences between two people who are already interacting with one another (Charafeddine et al., 2014); in that work, children used a known dyad's recent social history to reason about each individual's posture. The present study establishes that 3-year-old children also view posture as indicative of an individual's power, even when that person is not socially engaged with others.

The separate trajectories of children's sensitivities to powerful faces and postures suggest that they may have quite different origins in development. The fact that children did not respond consistently to faces until 4 years casts doubt on the proposal that judgments of power from facial structure are the output of an evolved mechanism reflecting ancestral social patterns (Van Vugt & Grabo, 2015). At the very least, that mechanism is either not initially sensitive to the specific facial features used here or may be timed with additional biological or social processes occurring at approximately the 4th birthday. It is possible that future investigations with younger children may reveal an even earlier sensitivity to relevant aspects of facial structure; for instance, studies could ask about characteristics other than strength and authority or employ additional nonverbal procedures. However, our methods allowed even the youngest children that we tested to demonstrate consistent interpretations of powerful postures. Thus, the timing documented here is consistent with the limited data that is currently available in younger children: Infants do not show a visual preference for either "dominant" or "subordinate" faces (even though they do show a preference for "trustworthy" faces modeled with a similar technique; Jessen & Grossman, 2016).

In contrast, children's early sensitivity to body postures reveals a much earlier developmental trajectory than the one observed for facial structure – and is compatible with proposals for an evolved mechanism for judging power from bodily appearance. Although no research has yet investigated this issue in children younger than 3 years, the mapping between expansive posture and strength may have a similar origin to another appearance-based inference about power. Preverbal infants use the relative size of two agents to predict the outcome of physical conflicts between them (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011). Given that many non-human species use posture to enhance their apparent size (Maestripieri, 1996; Mazur, 1985; Mech, 1999; Weisfeld & Beresford, 1982), it may be that postural information coopts adaptations supporting predictions about true physical power. A key question for future research is thus whether expansive posture is linked to strength by affecting an individual's apparent size, or whether an expectation that body information reflects physical power may heighten children's sensitivity to culturally-provided associations between expansive posture and strength.

Despite their possibly different origins, however, children's sensitivities to these aspects of facial structure and body posture are soon integrated into a single, coherent representation of how powerful people appear. By 4 years, children saw correspondences between powerful faces and bodies. Notably, this occurred at the same age that children became sensitive to both cues individually. Such rapid integration likely reflects children's motivation to build increasingly detailed representations of how powerful people appear.

As a signature of developmental change, children's rapid integration of power cues also highlights a mechanism that may support children's acquisition of adult-like intuitions about powerful appearances. Over & Cook (2017) have proposed that children's mapping between variation in facial structure and traits like "dominance" is based on cultural learning. If faces and bodies frequently co-occur in children's cultural input, then children's early sensitivity to postural expressions may actually scaffold their interpretation of power-relevant variation in facial structures. Future research should examine whether children generalize characteristics that they infer from certain body postures to the faces that are frequently paired with them in their daily experiences, or whether it is the ability to infer the same characteristics from faces and body postures that supports the integration of these cues into a single representation. Moreover, to better understand how children construct increasingly complex representations of powerful people, future research should also investigate whether other power-relevant cues, such as height, musculature, or vocal modulation (Pietraszewski, Wertz, Bryant, & Wynn, 2017), are also integrated with the representations examined here – and on what timeline this integration occurs.

Recognizing Multiple Forms of Power

We also examined children's reasoning about different sources of power. Prior research has only demonstrated that young children use variation in facial structure to determine "strength" and variation in body posture to determine who is "in charge" (Brey & Shutts, 2015; Charafeddine et al., 2014; Cogsdill et al., 2014). In addition to replicating these earlier findings in 4- and 5-year-old children, we also assessed the complementary inferences for the first time. At these same ages, children

attributed both strength *and* authority from facial structure *and* body posture. This complete pattern suggests that young children's conceptions of power weave together notions of both physical formidability and normative authority. Yet the judgments made by both younger children and adults revealed different sets of intuitions, indicating that this interwoven conceptual structure is neither how power understanding first emerges nor how it matures.

Several observations suggest that children initially view an individual's appearance as more indicative of physical strength than authority. First, at the youngest age we tested, 3-year-old children treated expansive posture as evidence for strength but had no consistent intuitions about authority. It is unlikely that this pattern can be explained by a misunderstanding of what the experimenter meant by "in charge". We offered a definition that 3-year-old children have understood in prior work (e.g., Brey & Shutts, 2015) and confirmed their comprehension here. Second, even once children inferred both strength and authority from physical appearance, they had significantly more consistent intuitions regarding strength. Third, in Experiment 2, out of all four cue/attribution combinations we examined, the ability of 4-year-olds to match powerful faces and bodies was uniquely associated with the extent to which they viewed powerful faces as "strong". This is notable because 3-year-olds already infer strength from body posture. Apparently, when children first integrate powerful faces and bodies, they view such appearances as characteristically strong, not "in charge".

The precedence of strength attributions bears on existing theories regarding the development of power concepts. Contrary to one developmental perspective,

children's initial assessment of a person's strength does not necessarily engender notions of authority (Lukaszewski, et al., 2016). Yet the present results do accord well with Sell et al.'s (2009) proposal that humans possess early-emerging, specialized capacities for assessing the physical formidability of other agents. Research on infants' reasoning about power is also consistent with this view. In the first year, infants attribute dominance based on an agent's personal size or the size of the group to which it belongs (Pun, Birch, & Baron, 2016; Thomsen et al., 2011) – both clear indices of formidability. In the second year, they also use third-party observations of physical contests to predict an agent's future victories and resource control (Enright, Gweon, & Sommerville, 2017; Mascaro & Csibra, 2012); these inferences may also derive from formidability assessment and expectations for the assertion of physical power. It will be important for future research to directly investigate when, and in what social contexts, young children first recognize that purely normative forms of authority are possible, distinct from the ability to physically enforce one's will (Cheng, Tracy, Foulsham, Kingstone, & Henrich, 2013; Chudek, Heller, Birch, & Henrich, 2011; Henrich & Gil-White, 2001).

The present study also demonstrates that our reasoning about different forms of power continues to develop after the preschool years. Five-year-olds and adults have similar intuitions about faces but diverge sharply in what they infer from body posture. Specifically, 5-year-olds attributed both strength and authority to people holding expansive postures, but adults only attributed authority. One possible account for this change is that adults come to distinguish between immutable physical characteristics and expressions that can vary across contexts. Whereas inherent

features like facial structure may give rise to multiple notions of power, adults' impressions of outward expressions like posture may be more restricted. Although children may not yet realize it, even people who are not strong can adopt the poses of those who are in charge.

Conclusion

To navigate risky social environments, adults make rapid judgments about the power of others from limited social information like physical appearance. Some of adults' inferences from appearance are accurate (e.g. judgments of physical strength: (Lukaszewski et al., 2016; Sell et al., 2009), while some of these inferences appear dubious (e.g., judgements of trustworthiness and authority: Oosterhof & Todorov, 2008; Zebrowitz, 2017). Regardless of their veracity, adults' judgments are highly consistent across observers and have powerful downstream effects on social cognitive processing (Abir, Sklar, Dotsch, Todorov, & Hassin, 2017). In the current study, we examined the development and conceptual structure of children's judgments to better understand the origins of adults' intuitions.

Like adults, children also estimate a person's power from their appearance and appreciate that power takes many forms. However, the trajectories of children's sensitivity to different cues, as well as the specific meanings that they ascribe to what they see, are distinct, likely reflecting a range of innate and learned mechanisms. Because children's earliest intuitions link body posture with physical strength, an early-emerging capacity for formidability assessment may contribute to their later attributions of more normative forms of authority. Children's intuitions about powerful faces comes later, but more research is needed to determine the

developmental mechanisms supporting their acquisition. Future work may benefit from assessing children's judgments about a broader range of power-relevant concepts (e.g., decision-making power, and possessing resources) and utilizing additional non-verbal methods to those employed here.

Another important consideration is that we deliberately focused on children's intuitions about apparently male faces and bodies. We made this decision to provide continuity with the bulk of extant research with both adults and children. However, a recent study hints that adults are more likely to conflate notions of strength and authority when assessing male, relative to female, faces (Toscano et al., 2016). Future work should investigate the earliest instances of this tendency, as well as the gender-specificity of the other development patterns documented here, to better understand the cultural and evolutionary forces that shape adults' conceptions of power.

Overall, children are clearly interested in knowing who is powerful. Four-year-olds hold integrated representations of powerful people – ones that connect masculine facial features and expansive postures. At this same age, children view people possessing or enacting these cues as both strong and in charge. Thus, the present study demonstrates that young children are attuned to some of the same aspects of physical appearance that adults find powerful and draw inferences from these cues to both physical and social power.

Tables

	Attribution Task						Task Correlations	
	trial type	*M*	*SD*	*t*	*df*	*p*	d_z	*r*	*df*
3-year-olds	Faces - strength	.56	0.33	1.08	31	.288	0.19	.051	30
	Faces - authority	.48	0.32	0.34	31	.740	0.06	.185	30
	Postures - strength	.64	0.36	2.16	31	.039	0.38	.260	30
	Postures - authority	.52	0.40	0.27	31	.792	0.05	-.163	30
4-year-olds	Faces - strength	.85	0.20	9.74	31	< .001	1.72	.631 ***	30
	Faces - authority	.69	0.34	3.22	31	.003	0.57	.176	30
	Postures - strength	.89	0.20	11.33	31	< .001	2.00	.264	30
	Postures - authority	.72	0.41	3.02	31	.005	0.54	.247	30
5-year-olds	Faces - strength	.88	0.24	9.08	31	< .001	1.61	.352 *	30
	Faces - authority	.81	0.31	5.65	31	< .001	1.00	.653 ***	30
	Postures - strength	.94	0.16	15.45	31	< .001	2.73	.114	30
	Postures - authority	.84	0.32	5.91	31	< .001	1.05	.466 **	30

Table 1. Mean percent of trials in which children selected the anticipated character on each trial type followed by one sample t-tests comparing children's average response to chance (chance = .50). The rightmost columns display bivariate correlations between children's performance on the matching task and each trial type of the attribution task. * $p < .05$, ** $p < .01$, *** $p < .001$.

Figures

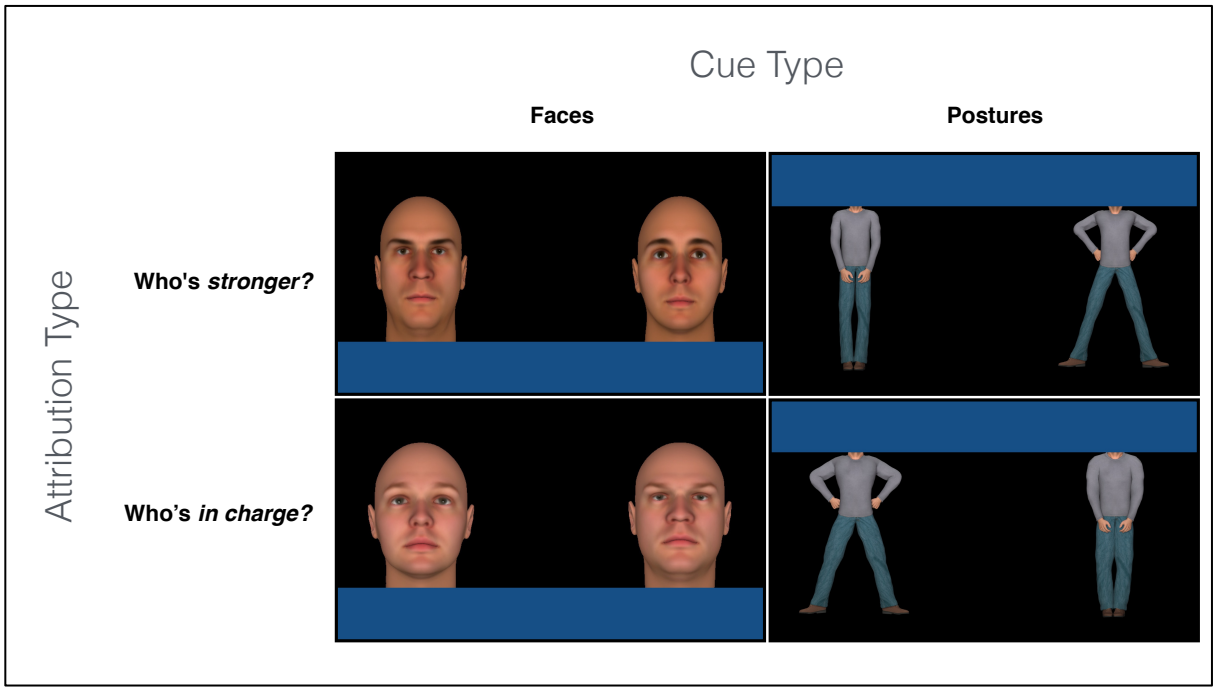

Figure 1. Examples of stimuli from Experiments 1 and 2.

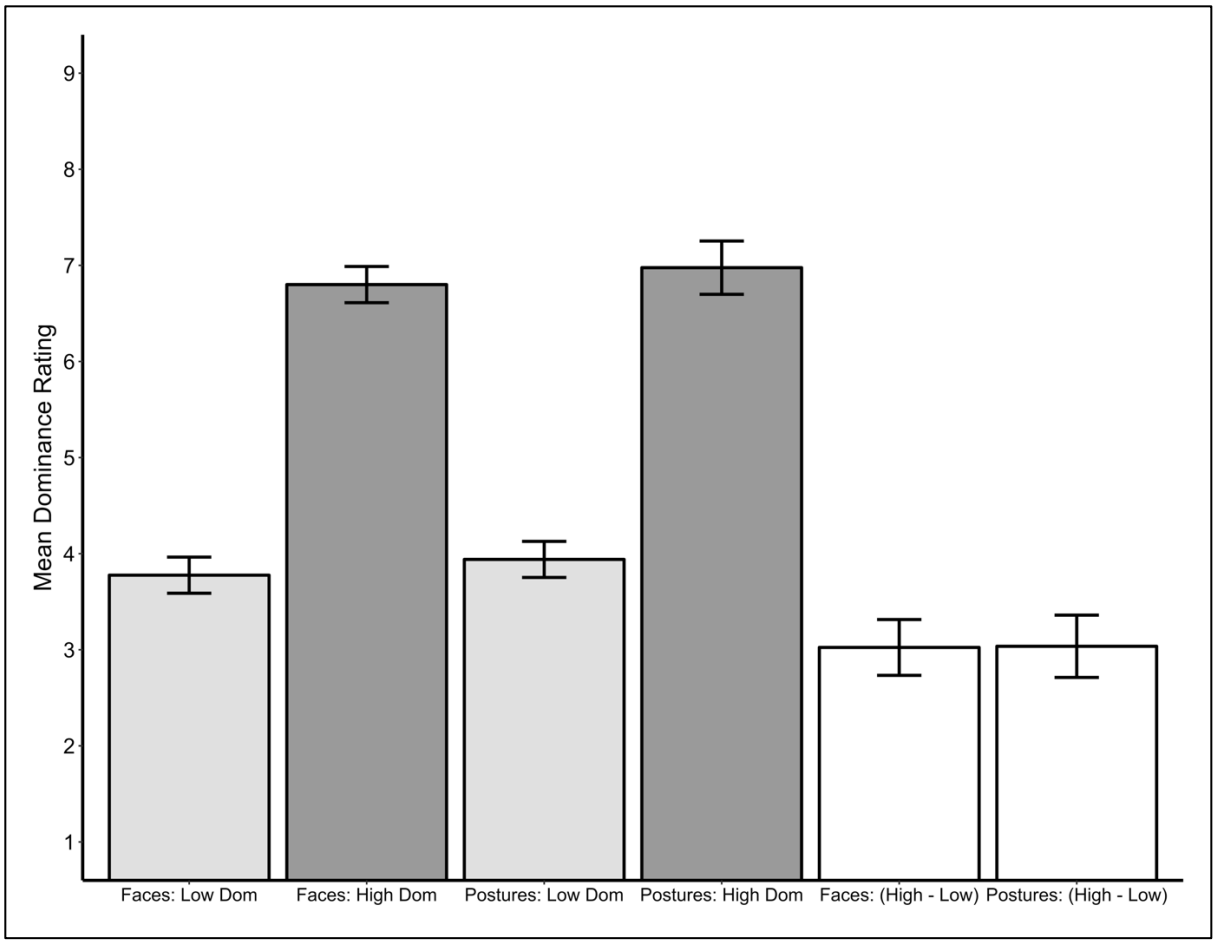

Figure 2. Mean "dominance" ratings and difference scores (High – Low) for the final selection of high and low power faces and postures from Experiment 1's norming study. Error bars are +/- 1 standard error of the mean.

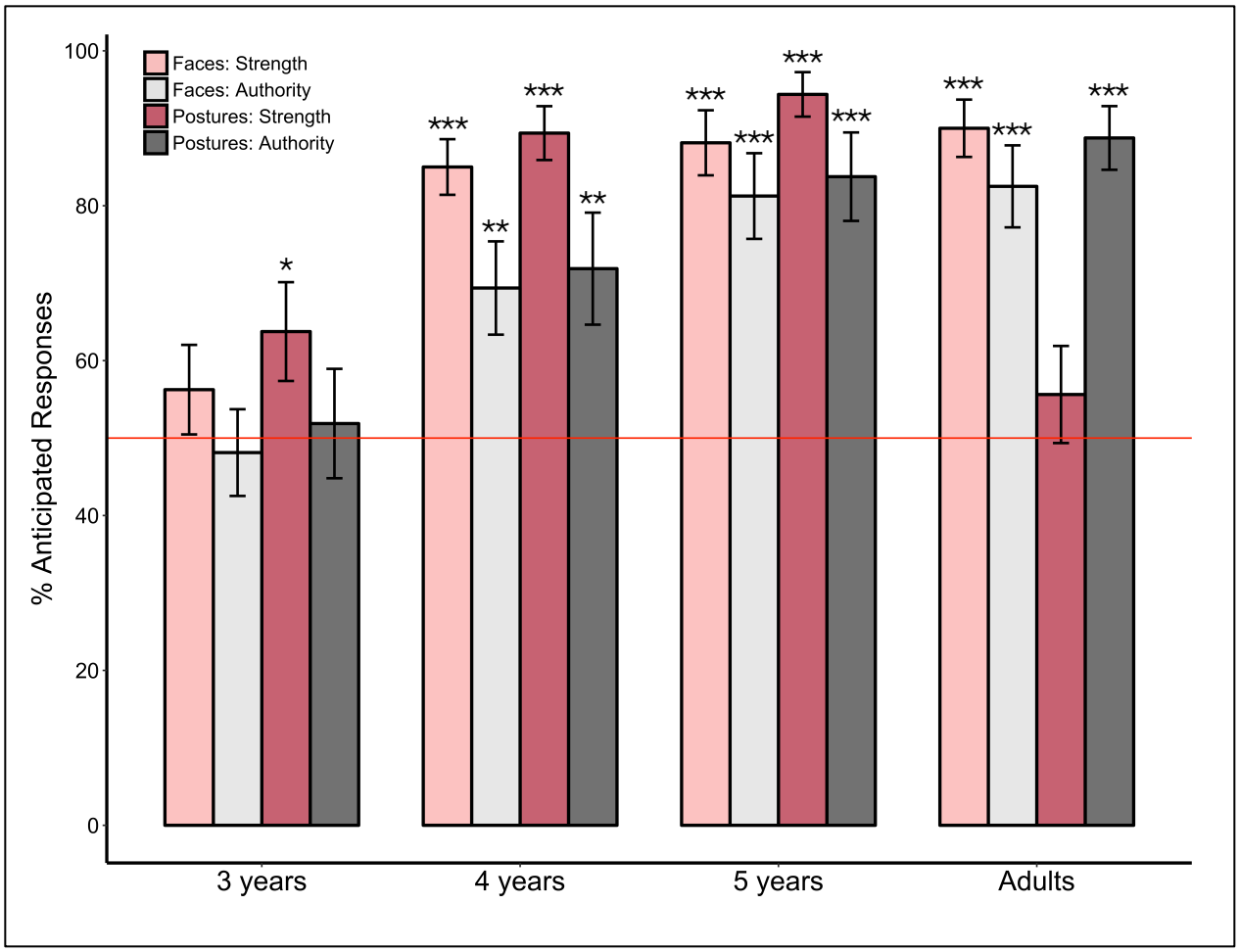

Figure 3. Mean percent of participants who selected high power faces and bodies for each question type in Experiment 1 and Experiment 2's Attribution Task. Error bars are +/- 1 standard error of the mean. *$p < .05$, ** $p < .01$, ***$p < .001$

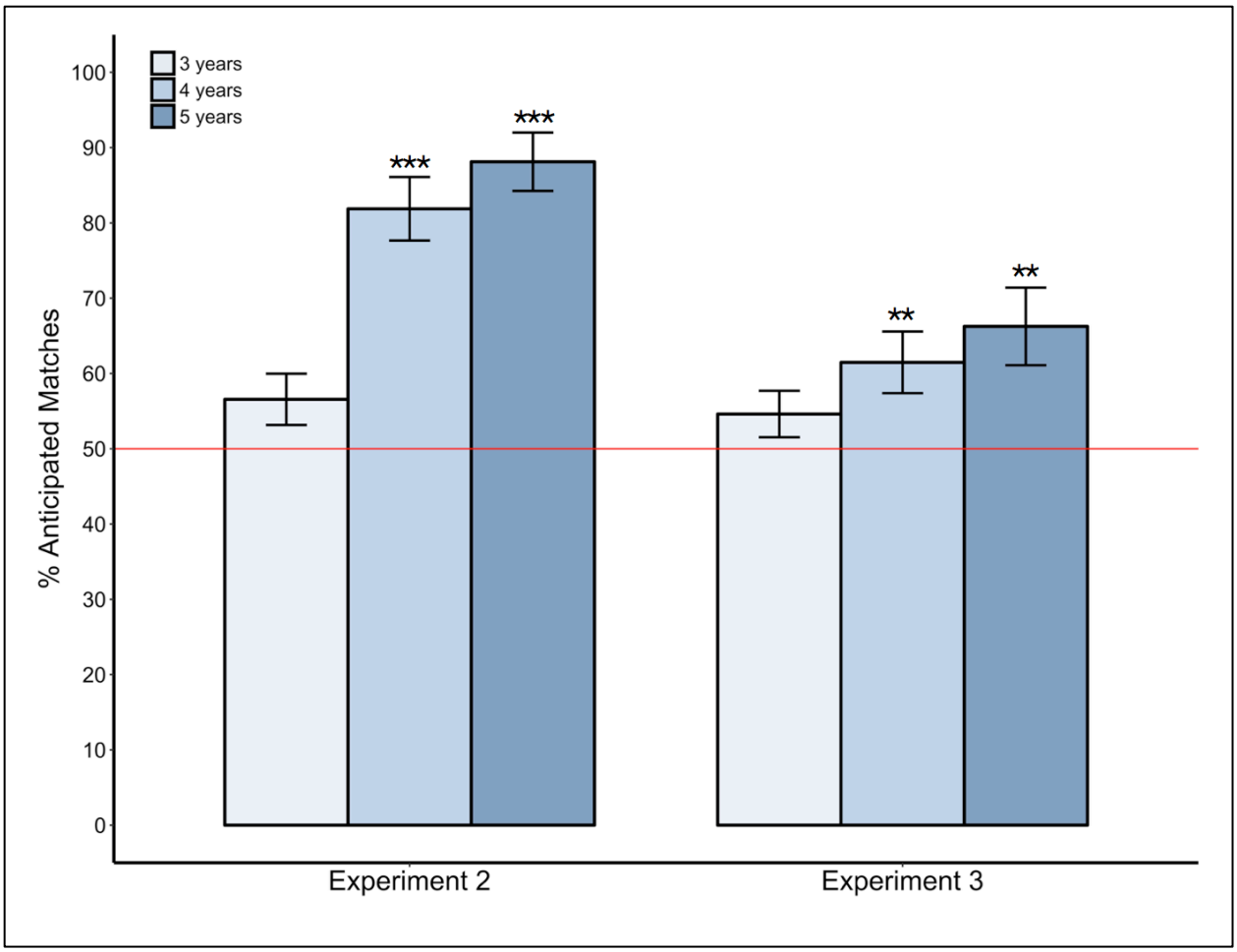

Figure 4. Mean percent of trials in which children placed powerful faces on powerful bodies. Error bars are +/- 1 standard error of the mean. *$p < .05$, ** $p < .01$, ***$p < .001$

Chapter 3: Expanded Discussion

The prior chapter's discussion was written under considerable space constraints. Because of this, here I expand on some of the conclusions, discussion points, and future directions mentioned earlier.

In contemporary society, people derive power from many sources. In the current study, I investigated children's judgments about two different forms of power that are highly relevant to humans' social interactions: physical formidability and authority. Adults' judgments of power from others' appearance reveal that they sometimes associate physical strength with authority. Researchers investigating adults' judgments have explained these relations by alluding to an innate, evolutionarily specific conceptual structure. However, there has been a dearth of developmental work attempting to actually elucidate the origins of these tendencies. Like adults, children also associate different forms of power with physical appearance, but do their judgements also associate physical strength with authority? The current study was motivated by this question, with the aim of elucidating the conceptual framework underlying children's and adults' understanding of power.

One of the most striking observations from the current study was that young children use multiple aspects of appearance to assess a person's physical strength and authority. However, several features of children's judgments show that they more readily associate some aspects of appearance with strength rather than authority. When interpret alongside related findings, these observations push us closer to at least three general conclusions about young children's understanding of power.

1. Young children possess conceptual representations of both strength and authority.
2. Though children will, at time, apply these different notions to the same types of people, these notions are conceptually distinct from one another.
3. More speculatively: Children's ability to detect and reason about instances of relative formidability precedes ability to detect and reason about instances of relative authority.

Below, I describe in more detail how the current study and related work supports these conclusions.

Children Distinguish Formidability and Authority

Young children appreciate that power takes many forms. By approximately the 3rd birthday, they possess distinct conceptual representations of at least the physical formidability and normative authority of other people. In both the current study and related work, this conceptual distinction is revealed in many ways. First, children draw on different types of social information to determine if someone is either "strong" or "in charge". For example, powerful postures engaged 3-year-olds' conceptions of physical strength without also engaging their conceptions of authority. As mentioned in the previous chapter, it is not likely that this pattern resulted from simply failing to understand what it means to be "in charge". All of the children included in the final analyses stated that they knew what being "in charge" meant and there are multiple demonstrations of 3-year-olds showing consistent responding on tasks that used terminology and definitions similar to ours (Brey & Shutts, 2015;

Charafeddine et al., 2014; Gülgöz & Gelman, 2015). In these tasks, three-year-olds have demonstrated that they someone is either "in charge" or "the boss" if they have more resources than others (Gülgöz & Gelman, 2015), deny permission to others (Gülgöz & Gelman, 2015), have decision-making power (Charafeddine, 2014), provide instructions (Charafeddine, 2014), and have privileged knowledge about the names and functions of objects (Brey & Shutts, 2015). Crucially, in each of these studies, children under 4 have only provided consistent responses after either observing a character enact his or her authority or by listening to verbal descriptions of these behaviors. Additionally, 3-year-olds do not readily make inferences from physical formidability to authority. For example, Charafeddine and colleagues (2014) observed that 3-year-olds do not think that someone who consistently wins physical contests is "the boss". Thus, while 3-year-olds have a clear understanding of relative authority, they more readily associate this type of power with the specific behaviors and interaction patterns occurring between people. These behaviors closely resemble those described by the definition of authority that used: being able to make rules and tell others what to do. Three-year-olds' inability to apply this notion of power in either the current, or similar studies (Brey & Shutts, 2015) indicates that they have not yet associated relative authority with the specific aspects of appearance that we showed them. As another indication of conceptual distinction, once children associate multiple notions of power with a single cue, that cue may not engage different notions of power to the same extent. For example, 4-year-olds attributed both strength and authority to both powerful faces and postures. However, children in this age group had stronger intuitions about the relative strength of these characters.

This pattern of judgments reveals a conceptual framework that clearly distinguishes between strength and authority as these notions are not activated with equal weight.

Looking up in age, 5-year-olds' intuitions of strength and authority were much closer for faces and postures. Does this mean that older children fail to distinguish between "strength" and "authority", or did they think that the experimenter was asking them the same question in different ways? No. Despite older children's tendency to pick the same types of people for both question types, there are hints that they also more strongly associated these cues with physical strength. First, although 5-year-olds' attributions of strength and authority were statistically indistinguishable, the overall pattern of their attributions was numerically similar to 4-year-olds' attributions. Second, 5-year-olds' judgments from faces were indistinguishable from adults' judgments. Adults' mental representations of the facial appearance of physically strong and socially dominant males are highly similar (Toscano et al., 2016). Nevertheless, adults clearly know that being "strong" and being "in charge" mean different things and adults clearly distinguished between strength and authority in their interpretations of expansive postures. In addition, despite the similarity in adults' representations of strong and dominant faces, it is possible to construct faces that differentially engage adults' judgments of either physical strength and social dominance (Toscano et al., 2016). Thus, 5-year-olds' tendency to identify both masculine faces and expansive postures as both strong and in charge suggests that children in this age group have come to associate, but not conflate, these different forms of power.

Third, drawing children's attention to these different forms of power has dissociable psychological consequences such as liking and approaching, or not liking and avoiding a powerful person. For example, Thomas and colleagues (under review) have observed that toddlers exhibit a social preference for powerful characters that achieve their goals through others' deference (presumably a benevolent form of power resembling normative authority). In this study, toddlers were initially familiarized with two characters coming face-to-face on a narrow platform. Upon encountering each other, one character bowed out of the way, allowing the other character to proceed across the platform. Later, when given the opportunity to select one of these characters to play with, toddlers consistently chose to play with the character that had been allowed to cross the stage. However, this preference disappears when a character achieves their goals through physical force. In a separate condition, the same two characters came together on an identical platform. However, rather than bow out of the way, one character was forcefully knocked to the side by the other character. This forceful character then successfully crossed the platform. After viewing this scenario, toddlers' preference actually flipped, and they now reliably chose to play with the character that had been knocked down.

Comparing children's attitudes towards characters that are either "strong" or "in charge" would provide a nice complement to the methods that we employed. These methods may provide convergent support for the conceptual framework outlined above by showing that children have differences preferences or attitudes based on the source of someone's power.

Formidability First

Social psychologists have recently proposed that the associations that adults see between strength and authority reflect an innately specified conceptual structure (Lukaszewski et al., 2016; Murray, 2014; Toscano et al., 2016, Van Vugt, 2006; Van Vugt & Grabo, 2015). The logic to this proposal is as follows: In ancestral periods, physically formidable group members were capable of generating within-group benefits that less formidable group members could not have generated. Because of this, people that were physically strong were also likely elevated to positions of leadership. Over evolutionary time, this continued relation between physical strength and within-group status has shaped an innate "followership" psychology. The contents of this psychology predispose humans to accurately gauge physical strength form appearance, and spontaneously attribute or confer greater social status to people that appear strong (Lukaszewski et al., 2016; Van Vugt & Grabo, 2015).

This just-so evolutionary story is intuitively plausible, and the adult data is fairly clear: Cross-culturally, adults appear to indeed associate physical formidability with various status- and leadership-related predictions. However, these psychologists have not appeared to consider the sheer complexity of this putative innate structure. What they propose assumes innate conceptual representations of physical strength, innate representations of authority, mappings between these concepts, and additional information identifying the physical correlates of these traits. Despite children's precocious ability to detect and reason about different forms of power, observations from both the current study and related work make this innate conceptual structure unlikely.

First, the weight of empirical evidence suggests that children do not associate physical strength with authority before they are 4. In the current study, 3-year-olds associated expansive postures with physical strength but not authority and it was not until 4 that children selected either powerful faces and postures as both "strong" and "in charge". Further, an exploratory analysis revealed that it was not until 4 that correlations emerged between children's judgments of both strength and authority to either of these cues (4-year-olds: Faces: Rho = .51, p = .003, Postures: Rho = .02, p = .91). As mentioned earlier, children younger than 4 do not even use direct behavioral evidence about physical strength or fighting prowess to identify "the boss", though 4- and 5-year-olds do (Charafeddine, 2014). These findings cast doubt on whether humans possess an innate conceptual structure which associates these distinct forms of power.

Still, even if there are not innate associations between these concepts, it is still possible that infants are born with innate representations of each. However, the weight of empirical evidence suggests that children's representations of physical strength and authority have different origins in development. Specifically, whereas the ability to detect and reason about relative differences in strength appear in early infancy, the ability to detect and reason about instances of relative authority appear in early childhood.

In the first year, infants use both an agent's physical size and number of allies to anticipate the outcome of physical conflicts (Pun, Birch, & Baron, 2016; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011). In the second year, infants create hierarchical orderings of agents based on relative formidability (Mascaro & Csibra,

2012, 2014) and reason about how differences in strength influence social outcomes outside of a physical contest. For example, although infants have a general expectation that resources will be distributed equally (Geraci & Surian, 2011; Schmidt & Sommerville, 2011; Sloane et al., 2012), this expectation is modulated by an agent's ability to exert their physical dominance over another agent. Specifically, 17-month-olds expect that when one character repeatedly wins a physical contest with another agent, the winner will receive the bulk of the rewards that are later distributed between them (Enright, Gweon, & Sommerville, 2017). Finally, in the current study, we see that children associate the specific cues that we showed them with physical strength both before and to a greater extent than they also associated these cues with authority. These results demonstrate an early emerging ability to both detect and reason about the physical and behavioral correlates of physical strength, as well as early emerging intuitions about the broader social outcomes for formidable people. But what about the question of innate foundations? Where does this early sensitivity come from?

It is possible that infants' early sensitivity to physical formidability has its origins in infants' early experiences, perhaps as a result of their failed attempts to act on the physical world. Consider human infants' early experiences and competencies. Infants are unable to either grasp or manipulate objects efficiently until approximately 5 months of age (Thelen et al., 1983). Because of this, their ability to both obtain and lift most objects is likely facilitated by adults' repeated intervention. We can speculate that such interventions might plausibly provide the initial evidence that infants need to associate physical strength (i.e., lifting capacity) with cues like overall

size. However, it is not obvious how these experiences allow infants to reason about or generate expectations of the outcomes of competing agents. Perhaps the above social psychologists are getting only part of the story right, and it is this very specific competency that has its origins in our species' violent evolutionary history.

Infants' early ability to associate overall size with physical formidability accords well with claims that humans possess evolved capacities for determining the strength and formidability of conspecifics (Sell et al., 2009, 2010). Prior to recent developmental work, the claim that humans possessed such innate capacities depended on three sources of evidence: Empirical demonstrations of adults' deftness at estimating others' physical strength (Lukaszewski et al., 2016; Sell, 2009), the prevalence and organizational role that physical conflict plays in closely related primate species, and anthropological and bioarchaeological evidence suggesting that interpersonal violence and intergroup warfare has been constant in humans' evolutionary history (Manson et al., 1991; Keeley, 1996; Wheeler, 2001). By hypothesis, both the prevalence and social function of violence in human societies over our evolutionary history has exerted continued selective pressure for such capacities (Tomasello, 2016). Although this story is largely speculative, in an extensive bioarchaeological survey Wheeler (2001) notes that, "The search for an earlier, less violent way to organize our social affairs have been fruitless."

A major contribution of the current study is that it complements recent infant work so that we can begin to articulate the specific formidability-relevant information that humans initially attend to. Here we show that 3-year-olds view expansive posture

as an indication of physical strength, but we can only speculate about the reasons why.

It is likely that children interpreted relative postures in the same way that infants treat relative physical size. Many of aspects of our stimuli may have contributed to this interpretation. In the absence of dynamic motion (e.g., people actually assuming different postures), children may have treated this pose as an inherent feature. Because the characters did not start from a neutral expression (showing that they were in fact identical in size) younger children may have thought that one person was genuinely larger than the other. Given that young infants show related inferences and neither infants nor 3-year-olds appear sensitive to differences in powerful facial structure, humans' initial representations of formidability appear closely related to representations of overall size.

In contrast to humans' early-emerging ability to reason about physical formidability, the ability to detect and reason about more normative forms of authority appears in early childhood. Preschool-age children are able to reason about relationships defined by relative authority when these relationships are clearly stipulated (Laupa & Turiel, 1986; Leman & Duveen, 1996, 1999). In addition, children appreciate that rules should be applied in an agent-neutral way in the contexts of games (Rakoczy, Brosche, Warneken, & Tomasello, 2009; Rakoczy, Warneken, & Tomasello, 2008, 2009; Schmidt, Rakoczy, & Tomasello, 2011). However, appreciating that certain behaviors and actions have normative force is distinct from appreciating that a specific subset of people possesses normative authority. Whereas the former type of reasoning rest on acting according to rules that

are jointly established, the latter requires recognizing that only a subset of individuals are capable of actually imbuing behaviors with normative force.

By 4, children appear biased to learn rules from people that they perceive as competent (Rakoczy, Hamann, Warneken, & Tomasello, 2010; Rakoczy et al., 2009) and think that adults, but not children, are capable changing rules once they are established (Zhao & Kushnir, 2017). However, these findings shed little light on the inferences that children needed to make in the current study as the characters were designed to be identical in age and children had no direct evidence about the characters' relative competencies.

Returning to question of innate foundations, at the heart of understanding normative authority is the ability to take a normative stance toward peoples' behaviors. Though the ability to detect and reason about physical formidability is commonplace amongst animal species, normative thinking appears to be uniquely human (Chudek & Henrich, 2011; Tomasello, 2009). Besides us, no other animals either recognize or enforce social norms, suggesting that these capacities are an evolutionarily recent cognitive achievement (Rudolf von Rohr et al., 2011; Tomasello, 2009; Tomasello et al., 2005). What's more, the ability to recognize that behaviors can and should be enforced in an agent-neutral manner requires the ability to recognize the shared perspectives and internal values of different agents (Rudolf von Rohr et al., 2011; Tomasello, 2009) and it is debatable if infants possess such capacities (Tomasello et al., 2005).

In sum, young children appear to be sensitive to relative formidability much earlier than they are sensitive to instances of relative authority. Infants' early capacity

for formidability assessment may have its roots in innate conceptual representations shaped by humans' violent evolutionary history. These representations are likely both engaged and shaped by infants' early experiences with others. In contrast, young children's capacity to identify instances of relative authority emerges later and likely has its roots in humans' unique socio-cultural practices. To the extent that recognizing authority rests on innate capacities, these are likely capacities that facilitate acquiring culture (Tomasello, 1999). Appreciating relative authority may simply requires a more complex suite of cognitive capacities than recognizing strength. Identifying those with social power may require experiences of the culturally valued traits that grant some with normative authority.

Aligning Different Aspects of Powerful Appearance

To respond adaptively to other people, we must rapidly judge their emotional and intentional states. Adults are deftly attuned to such states, and this sensitivity rests in part on fluidly integrating information distributed across the entire body. In particular, adults are highly adept at reading signals from both facial and postural expressions and are quickest to diagnose another's state when faces and bodies provide congruent information (de Gelder, de Borst, & Watson, 2014; Meeren, van Heijnsbergen, & de Gelder, 2005; Van den Stock, Righart, & de Gelder, 2007). These abilities do not result from a lifetime of experience however, as even infants possess similarly integrated, "whole-body" representations of emotional expressions.

By approximately 6 months of age, infants have specific expectations for the overall organization of human bodies and detect emotional correspondences between facial and postural expressions (Hock, Oberst, Jubran, White, Heck, & Bhatt, 2017;

Missana, Atkinson, & Grossmann, 2015; Zieber, Kangas, Hock, & Bhatt, 2014). Although infants do not have the same flexibility that adults have in their behavioral responses to these signals (e.g., they cannot easily avoid interacting with someone who is angry) it is thought that these representational capacities support adaptive responses to others' emotions and intentions across the lifespan (Bhatt et al., 2016).

The current study is the first to investigate whether children also see correspondences between different aspects of powerful appearance. Across two experiments, 4- and 5-year-olds' reliably matched powerful faces and bodies together revealing a level of representational sophistication not unlike the sophistication exhibited in their representations of emotional appearance. Because these representations can be activated without prior experience with our stimuli (Experiment 3), they are likely to have immediate consequences for children's adaptive participation in the social world. On the basis of a single cue, "whole-body" representations of powerful appearance may allow children to estimate other aspects of appearance that cannot (or have not yet) been seen. In addition, the specific ages at which children match different powerful cues together can shed light on the cognitive capacities that allowed them to do so. Particularly, because 3-year-olds' ability to label faces and postures in isolation was poor relative to older children, along what dimension did they successfully align these cues together?

Cogsdill and colleagues (2014) suggest that trait judgments from faces may be grounded in lower-level judgments of emotion or valance. Although some of adults' trait judgments from faces (e.g., "trustworthiness") are highly correlated with

judgments of valence (defined along the dimension of niceness/meanness), it is unlikely that emotional understanding or attributions of valence can explain the full range of adults' judgments from appearance. For example, adults' trait judgments of "dominance" are less closely related to valence (Oosterhoff & Todorov, 2008). Nevertheless, it is possible that representations of both valence and emotional appearance play a fundamental role in children's judgments of power, particularly in the age ranges that we tested. As a mechanism of developmental change, representations of both emotion and valence may scaffold children's mapping of power onto different aspects of appearance. These overlapping judgements of emotion and power may only later become dissociated as children get older. Although our study was not designed to distinguish between judgements of power and judgements of valence or emotion, comparing children's abilities across tasks can provide some initial insight into the relations between these distinct types of impressions.

In Experiment 2, 3-year-olds did not easily apply different notions of power to the cues that we showed them. In particular, though they attributed "strength" to expansive postures at rates that exceeded chance, they did not do this to the same extent for faces. However, because 3-year-olds successfully matched faces and postures and this tendency was not associated with their judgments from isolated cues, it possible that they did so by attending to judgements other than physical or social power. For example, Cogsdill and colleagues (2014) have also observed that 3-year-olds do not label powerful faces like the ones we used as "strong". However, 3-year-olds do interpret the same faces as "mean". Thus, it is possible that young

children judged either powerful faces or postures as "meaner" than the other character and aligned these cues on this basis. To more fully assess this possibility, future work will need to investigate whether 3-year-olds also interpret expansive postures as "mean". In the context of the current study, we saw that at least as children get older they become increasingly better at matching powerful faces and postures together. In addition, we saw hints that this tendency more directly results from attending to the specific dimensions of power that we asked about.

In Experiment 2, older children showed a greater facility than 3-year-olds at matching powerful faces and postures together. There were also indications that these tendencies relied more heavily on representations of power, rather than emotional or valenced appearance. Four-year-olds' matching scores were significantly greater than 3-year-olds' scores and were significantly associated with their judgments of strength from faces. This association between tasks suggests that their ability to match these cues relied on representations of power in ways that 3-year-olds' abilities did not. 5-year-olds' matching scores were statistically indistinguishable from those of 4-year-olds and also associated with judgements of strength from faces. However, this association was also joined by significant correlations with a wider range of appearance-to-power judgments, suggesting that older children likely matched different cues together by attending to power correspondences rather than correspondences of emotion or valence.

The Role of Gender in Children's Judgments of Power

Although adults often associate physical strength with authority in their first impressions of others, these associations appear to be strongest when evaluating males. For example, although adults' judgments of males' physical strength are positively correlated with impressions of within-group authority and other status-related predictions, judgments of females' physical strength are not also associated with status-related predictions (Lukaszewski et al., 2016). Further, although adults associate strength and social dominance to both male and female faces, they are more likely to confuse physical strength for social dominance when looking at male faces (Toscano et al., 2016).

To explain adults' difficulty in distinguishing between first impressions of males' physical and social dominance, these authors have alluded to selective pressures that have shaped the male phenotype. By hypothesis, male physical characteristics related to strength have evolved primarily to win physical contests over mating rights to females. In ancestral periods, privileged mating access led to greater within-group status. Social psychologists applying an evolutionary perspective to adults' judgments posit that the same forces acting on males' phenotypic expression have also shaped the conceptual framework underlying adults' impressions from male appearance.

Evolutionary hypotheses require empirical confirmation. If humans are predisposed to more closely associate male strength with status, we might see similar associations revealed in children's judgments. However, as argued earlier, there are empirical reasons to question whether people are even predisposed to see relations

between strength and authority, much less that such associations should be biased toward males. Moreover, because our stimuli depicted only male faces and bodies, the current study provided a direct test of whether children interpret male features as adults do. We found that children do not interpret male faces as adults do until approximately the 5th birthday. Further, children and adults had diverging intuitions about the power expressed by male postures. These observations suggest that adults' intuitions about the physical manifestation of power are neither fully established or fixed by childhood, inviting further research on the sources of adults' judgments.

One useful strategy would be to directly compare children's developing judgments of power across both male and female faces and bodies. Investigating children's judgments across multiple ages can help reveal the developmental timeline along which adults' gender-biased attributions emerge. Knowing the specific ages that such biases emerge can help to specify the developmental experiences that have shaped them.

Future Directions

The current study was the first to investigate children's judgements of how different forms of power relate to different aspects of appearance. The developmental patterns that we observed provided insight into the origins of adults' judgements, as well as the conceptual foundations upon which these judgements are based. However, the patterns that we observed were complex. Though children initially had stronger intuitions about how strength related to appearance, over a short developmental period, children showed similarly strong intuitions about authority. Moreover,

children's judgments diverged sharply from those of adults, indicating that our intuitions about the physical manifestations of power change during and beyond childhood. The sheer complexity of these patterns invites many questions.

An over-arching goal for future work must be to identify the specific mechanisms underlying the patterns of developmental change observed here. First, by what means do children initially map notions of strength and authority onto physical appearance? I have suggested that humans' early representations of strong appearance may have innate foundations, but that representations of normative authority may be grounded in children's early experiences. Future studies assessing the earliest instances of children's intuitions about the physical characteristics that establish authority could be helpful, as there have been no demonstrations of such competencies below 3 years of age. However, the challenge of uncovering earlier competencies rests in developing the appropriate nonverbal methods. A promising direction is to investigate which aspects of physical appearance lead to followership behaviors like imitation (Chudek & Henrich, 2011). However, an important component of normative thinking is the expectation that others will also conform to the standards demonstrated by those in charge. Thus, an additional challenge is sufficiently demonstrating that the same aspects of physical appearance that engender followership behaviors like imitation also engender the expectation that others will also imitate a perceived authority figure.

Second, because children were not initially sensitive to faces and postures at the same time, what experiences or representational capacities allow children to see correspondences between different cues? It is possible that children's everyday

experiences suggest that powerful faces and bodies go together. However, at least some of humans' trait judgments are grounded in judgements of valence and representations of emotion. Future work directly comparing children's developing judgements of power and more valenced attributions could be helpful in disentangling the relative contributions of both types of impressions. If children's judgments of power from faces and bodies are grounded in representations of valence, we would expect that valenced judgments of either the niceness or meanness of these cues should emerge first and become increasingly correlated with children's judgments of power.

Third, what is happening between childhood and adulthood? It is notable that judgements of physical strength from expansive postures was the only judgment that changed after 5. Because the current study did not track the lifetime trajectory of these intuitions, we can only speculate about both the trajectory and nature of this change. In the current study, we may be observing a critical moment in development when children entertain multiple notions of power, but they have not yet figured out how to accurately recognize each type. This inaccuracy may result from some lingering, but tenuous connections between impressions of power and impressions of emotions. But by what means are these connections finally severed? Perhaps the solution lies in acknowledging that adults just have more specific knowledge about how different aspects of appearance relate to distinct notions. For example, adults may just appreciate that others may try and exaggerate their physical characteristics to appear stronger and that both strong and weak people can choose to adopt the poses

of those that are in charge. Children's willingness to apply notions of both strength and authority to postures may simply reflect an ignorance of these facts.

As a mechanism for knowledge acquisition in this domain, perhaps as children grow, the assumption that posture is linked with strength fails them in their everyday experience. On this basis, the intuitive theory which initially sees connections between strength, overall size, and different body positions becomes revised, perhaps initiating the dissociation between more valenced impressions from those of power. An important first step to assess this possibility will be to simultaneously track judgments of power and valence in even older children to provide a fuller account of the changes and possible disentanglement of these judgments between childhood and adulthood.

Finally, what are the sources of the gender-specificity present in adults' judgments of power? The current study demonstrates that judgments of male strength and authority come closer together across the preschool years, but it is not clear why. Although both the salience and psychological consequences of attending to gender are meaningfully influenced by adults' pedagogy during this period (Hilliard & Liben, 2010; Shutts, Kenward, Ivegran, & Fawcett, 2017), no studies have assessed whether adult messages play a causal role in children's judgements about the physical manifestations of power. Thus, in addition to investigating the gender-specificity of the other development patterns documented here, comparing these judgements across typically educated children and those participating in gender-neutral preschool classrooms can further elucidate the evolutionary and cultural factors that shaped children's and adults' conceptions of power.

Appendices

Supplemental Information for: Children's Developing Judgments About the Physical Manifestations of Power

Norming Study

The aim of the norming study was to produce a stimulus set of 10 face and 10 body pairs to be used in the studies reported in the main text. To do so we first gathered adults' ratings of "dominance" toward images of individual faces and body poses. Second, using these ratings, we selected high and low power faces and body identities such that high power faces and bodies had similar dominance ratings, low power faces and bodies had similar dominance ratings, and the distances between dominance ratings for high and low power versions of each individual identity were constant.

Method

Participants. Twenty-five adult undergraduate students with normal or corrected-to-normal vision (15 females; M_{age} = 19.89 years, SD = .91 years) participated online for course credit. Eight additional participants who did not complete the study were excluded.

Materials. Face stimuli were drawn from a larger database of 25 male, computer-generated identities created by Oosterhoff and Todorov (2008). To produce this database, visually distinct facial identities were first drawn from a continuous face space; next, a transformation was applied to create a range of high and low power versions of each one (Figure S1). This transformation was derived from a

computational model capturing the aspects of facial structure that covary with adults' judgments of a face's "dominance". The outcome of this procedure is that faces high in dominance have mature, masculinized features (e.g., pronounced brow and jawline) while non-dominant faces (i.e., subordinate) have less mature, less masculinized features. Adults' impressions of faces from this database have been extensively validated and these images have been used as stimuli in many studies of dominance perception (for review, see Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015).

Body stimuli were drawn from a larger set of 12 male, computer-generated identities, created by the authors using Poser version 10. To produce this set, visually distinct identities were generated by adjusting the body type (e.g., girth, muscularity, etc.) of a standard body; next, the pose of each identity was manipulated to create a range of high and low power versions of each identity (Figure S1). The pose adjustments were based on prior research demonstrating that adults view people holding expansive postures as "powerful" and "in charge", and restrictive postures as "less powerful" and "subordinate" (e.g., Burgoon, 1991). The outcome of this procedure was that bodies with high power, expansive postures had their hands on their hips, their shoulders open, and their legs spread apart. Bodies with low power, restrictive postures had their hands crossed in front of them, their shoulders hunched, and their legs close together.

We prepared a total of 175 individual face images and 132 individual body images depicting a wide range of anticipated dominance ratings (i.e., 7 versions of each of the 25 unique face identities; 11 versions of each of the 12 unique body

identities). We added a blue horizontal bar to each face or body image. For face images, the bar was placed across the neck to reduce the appearance of a floating head; for body images, the bar was placed above the shoulders to occlude the head.

We asked participants to rate the "dominance" of each image because this term could reasonably apply to both stimulus types and could be interpreted as referring to either strength or authority.

Design and Procedure

On each of 307 trials, participants responded to the prompt, "how dominant is this person?" Participants' responses could range from 1 to 9. We grounded their interpretation of this scale by stipulating that a 1 meant "not at all dominant" and that a 9 meant "very dominant". To maintain continuity with prior research (Oosterhoff & Todorov, 2008), we encouraged participants to respond to each image with their gut reaction – i.e., not to spend too long considering any particular image and to answer as honestly and as quickly as possible.

Face and body images were rated in separate blocks, whose order was counterbalanced across participants. Within each block, the presentation order of images was determined by a random sequence that was generated automatically when an individual participant's session began.

After collecting adults' ratings of these individual images, we selected a final set of 10 face and 10 body identities, with each identity having one high and one low power version. The goal of this selection process was to ensure that all high power faces and bodies had similar dominance ratings, that all low power faces and bodies had similar dominance ratings, and that the distances between dominance ratings for

high and low power versions of each individual identity were constant. To support comparison to previously published studies, the selected high and low power version for each face identity was the +3 and - 3 SD dominance versions identified by Oosterhoff and Todorov (2008); selection of body images was thus anchored to the face ratings. The high and low power versions of all selected body identities were drawn from the +5 and -2 dominance versions we created earlier.

Results

Preliminary analyses confirmed that neither participants' gender nor the counterbalancing factor of seeing faces or bodies first influenced participants' ratings.

A 2 x 2 repeated measures ANOVA assessed the influence of (Power – High or Low) and (Cue Type – Faces or Bodies) on participants' dominance ratings. There was a main effect of Power $F(1, 24) = 137.66$, $p < .001$, $\eta_p^2 = .85$ and no main effect of Cue $F(1, 24) = 1.14$, $p = .297$, $\eta_p^2 = .05$. Crucially, there was no interaction of these factors $F(1, 24) = .001$, $p = .972$.. Thus, there was no indication that participants' ratings varied between face and body identities.

Discussion

The final selected stimulus set had excellent properties. As can be seen in Figure 1 of the main text, the goal of the selection process was met: Across face and body identities, all high power faces and bodies had similar dominance ratings, all low power faces and bodies had similar dominance ratings, and the distances between dominance ratings for high and low power versions of each individual identity were constant. In addition, the physical differences between high and low power versions

of each identity were sufficient, when viewed side by side, to create the impression that these were distinct characters.

Experiment 1

Additional Results

Preliminary analyses. A preliminary mixed ANOVA, with Attribution ("strong" or "in charge") and Cue (face or body) as within-subject factors, and with Gender, Attribution Order, Cue Order, and Stimulus Set Order (i.e., either of two pre-defined sequences) as between-subjects factors, examined the influence of gender and the counterbalancing factors on participants' judgments. There were no main effects of Gender or any of the counterbalancing factors. There was a three-way interaction between Attribution, Gender, and Attribution Order, $F(1, 17) = 9.64$, $p = .006$, $\eta_p^2 = .36$. Women tended to answer in the predicted manner for whichever attribution came first, whereas men tended to answer more consistently on questions about authority, regardless of which attribution came first. Because this was the only significant interaction involving gender or a counterbalancing factor, these factors were omitted from further analyses.

Figures. The frequency of participants selecting high power faces and bodies for each question type is presented in Figure S2.

Experiment 2

Additional Results

Attribution task.

Preliminary analyses. A preliminary 2 (Attribution) x 2 (Cue) x 3 (Age Group: 3-, 4-, 5-year-olds) x 2 (Gender) x 2 (Attribution Order) x 2 (Cue Order) x 2

(Stimulus Set Order) ANOVA examined the influence of gender and the counterbalancing factors on participants' judgments. There were no main effects of gender or the counterbalancing factors. There was a three-way interaction between Attribution, Cue, and Cue Order, $F(1, 48) = 8.82$, $p = .005$, $\eta_p^2 = .16$. When children viewed bodies first, their most consistent judgment was to indicate that people with expansive posture were stronger; when they viewed faces first, this view persisted but was also joined by highly consistent judgments of strength from facial dominance. Two higher-order interactions were also significant but difficult to interpret and likely spurious: Cue x Attribution Order x Stimulus Set Order x Age Group x Gender, $F(2, 48) = 3.54$, $p = .037$, and Attribution x Cue x Question Order x Cue Order x Stimulus Set Order x Age Group, $F(2, 48) = 3.62$, $p = .034$. Gender and the counterbalancing factors were not considered further.

Planned analyses within each age group. To further understand the nature of children's judgments within each age group, we conducted a 2 (Attribution) x 2 (Cue) repeated-measures ANOVA in each age group and conducted planned comparisons of children's responses to the next younger age group.

3-year-olds. There were no main effects of Attribution or Cue, and no interactions between these factors.

4-year-olds. There was a main effect of Attribution, $F(1, 31) = 6.71$, $p = .014$, $\eta_p^2 = .18$, indicating that 4-year-olds had more consistent intuitions about strength than authority. There was no interaction between factors. Four-year-old children's responses were significantly more consistent than 3-year-olds' responses when attributing both strength and authority from facial structure, $t_{strength}(62) = 4.22$, $p <$

.001, d_s = 1.06, $t_{authority}(62) = 2.58$, $p = .012$, d_s = .65, and strength from body posture, $t_{strength}(62) = 3.53$, $p < .001$, d_s = .88, and marginally more consistent when attributing authority from body posture, $t_{authority}(62) = 1.98$, $p = .052$, d_s = .50.

5-year-olds. There were no main effects of Attribution or Cue type, and no interaction between these factors. Although no scores were significantly different from the corresponding scores for 4-year-old children, all were numerically higher.

Figures. The frequency of children selecting high power faces and bodies for each question type is presented in Figure S2.

Matching Task.

Preliminary analyses. A preliminary 2 (Gender) x 2 (Initial Side: more powerful body on left or right on first trial) x 3 (Age) ANOVA assessed the influence of gender and the counterbalancing factor Initial Side on children's matching decisions, across ages. There was an interaction between Gender and Initial Side, $F(1,84) = 11.14$, $p = .001$, $\eta_p^2 = .12$. Girls performed somewhat better when the more powerful body was on the left side of the flipbook on trial 1. These factors were omitted from further analyses.

Figures. Figure S3 shows the distribution of matching scores for children in each age group.

Supplemental Figures

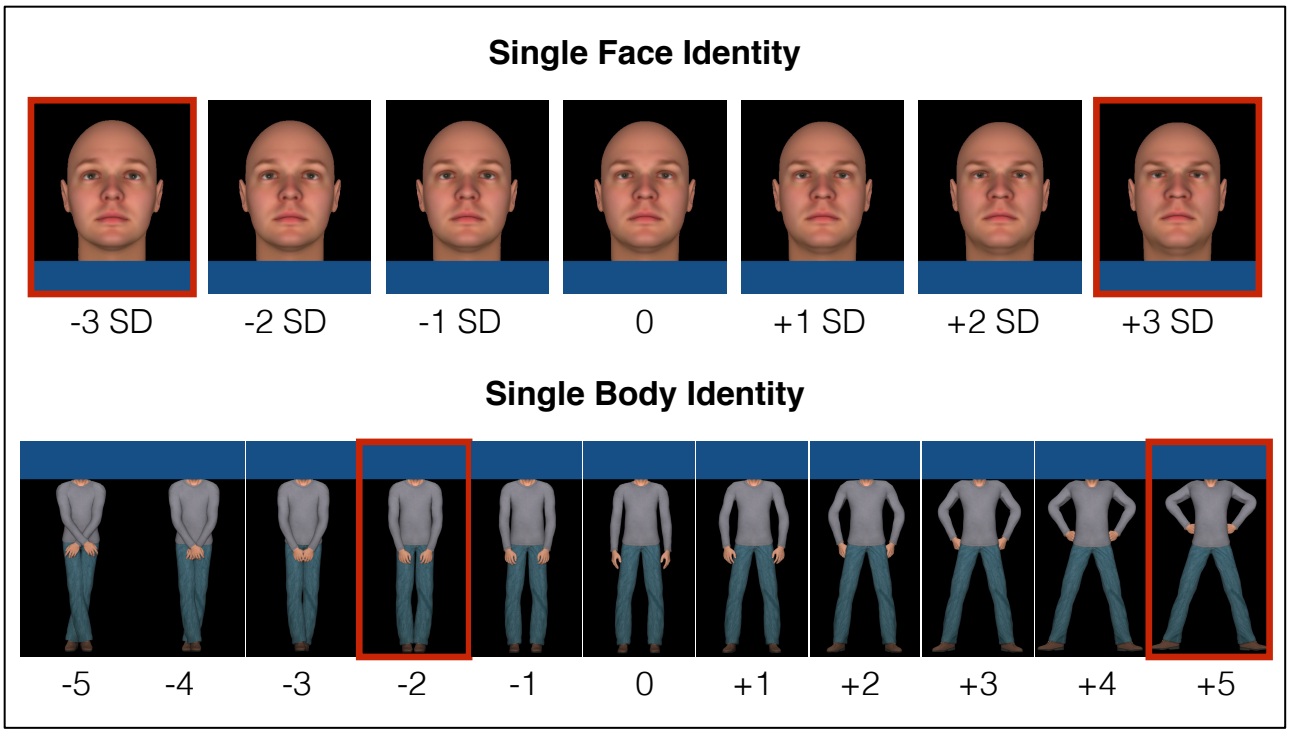

Figure S1. The full range of variation within an individual face and body identity, as presented in the norming study. All selected faces were drawn from the +3 and -3 SD dominance faces (red border) identified by Oosterhoff and Todorov (2008). All selected bodies were drawn from the +5 and -2 versions (red border) created by the authors.

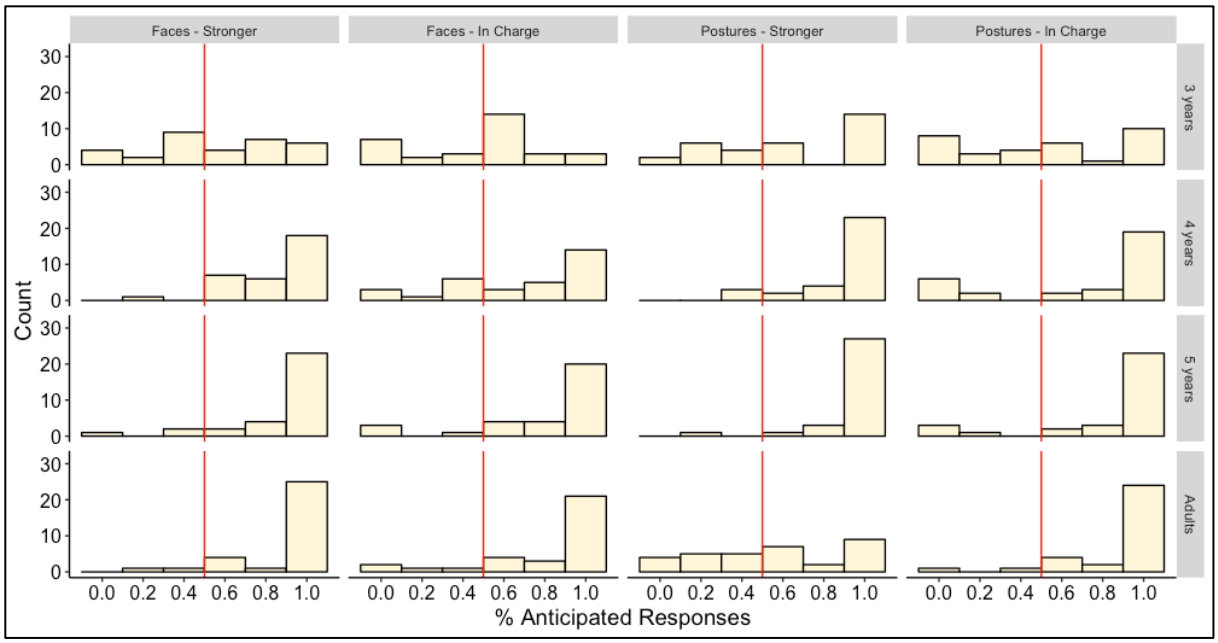

Figure S2. Frequencies of participants selecting high power faces and bodies for each question type in each age group in Experiments 1 (adults) and 2 (children).

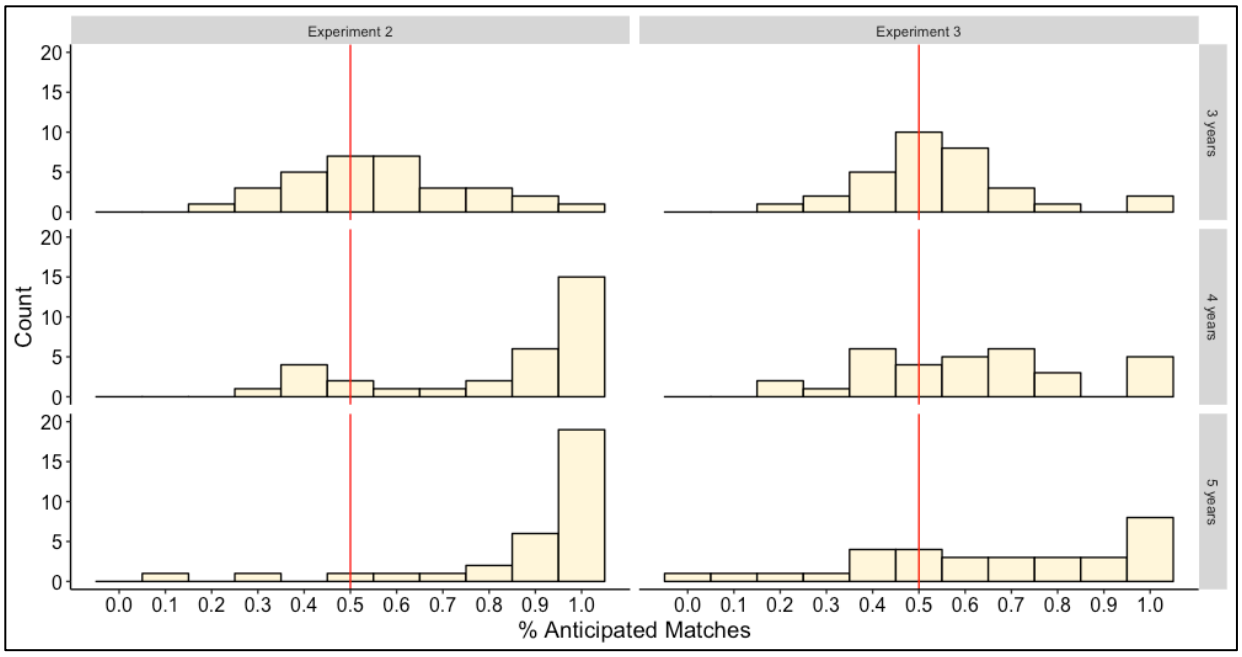

Figure S3. Frequencies of participants matching high power faces and bodies in each age group for Experiments 2 and 3

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