CHILD DEVELOPMENT PERSPECTIVES

Emerging Sensitivity to Socially Complex Expressions: A Unique Role for Adolescence?

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ABSTRACT—***Complex facial expressions provide signals about emotions that are related to nuanced social behavior (e.g., shame, desire) and inner thoughts (e.g., pensive). In this article, we review the empirical evidence evaluating whether the ability to recognize these complex expressions changes during adolescence, given the increasing evidence of heightened sensitivity to social signals during this time. We propose considerations for interpreting findings from this work and shaping research. Finally, we offer a new hypothesis about the influences of age and pubertal maturation on the development of processing complex facial expressions during adolescence, and propose that puberty influences the emergence of sensitivity to particular kinds of complex expressions, namely* social sexual expressions. *This hypothesis is embedded in a broader theory about how age-appropriate social developmental tasks, like forming loyal peer friendships and exploring romantic and sexual relationships in adolescence, influence face-processing behavior.***

KEYWORDS—*facial expressions; emotion; development; face processing; pubertal development*

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Beginning in infancy, humans use facial expressions as social signals. By adulthood, we are skilled in perceiving these signals and using them to predict and guide behavior. Many studies characterize the developmental trajectory of sensitivity to *basic* facial expressions (1), which provide signals about a specific set of universal emotions (2; see Table 1). In contrast, much less is known about developmental changes in the ability to detect and recognize nonbasic, or *complex*, expressions (see Figure 1), which provide signals about emotions related to more nuanced social behavior and inner thoughts (3). Recently, investigators have begun to ask whether sensitivity to these complex expressions changes during adolescence, given evidence of heightened sensitivity to social signals during this time, which may be modulated by pubertal hormones (4, 5).

In this article, we review research evaluating age- and puberty-related influences on processing complex expressions. We highlight the conflicting evidence and suggest considerations about this work to help interpret findings and shape research. We conclude with a new hypothesis about how age and pubertal maturation may influence the emerging ability to process complex expressions, and propose that puberty specifically influences sensitivity to particular kinds of complex expressions, called *social sexual expressions*. This hypothesis is embedded in a broader theory about how age-appropriate social developmental tasks influence face processing (6), particularly during adolescence (4).

REVIEWING THE RESEARCH

Developing competence in *emotion processing* includes the abilities to perceive, interpret, and understand emotions, and requires many component skills, like the ability to detect a range of cues like prosody, body language, and theory of mind (7). Here, we focus on a basic component of emotion processing: the ability to *visually perceive and categorize emotion expressions*, particularly complex (i.e., nonbasic) expressions. We argue that studying developmental influences on this level of emotion

Child Development Perspectives

Table 1
Distinguishing Basic From Complex Expressions

Feature	Basic	Complex cognitive	Complex social
Examples	Happiness, sadness, fear, anger, surprise, disgust	Thoughtfulness, boredom	Flirtatiousness, arrogance, guilt
Universality	Yes	Unclear	Unclear
Muscles of expression	Whole face	Primarily eye region	Primarily eye region
Amygdala damage	Little impact on categorization	Large impact on categorization	Large impact on categorization
Prefrontal cortex damage	Unknown	Little impact on categorization	Large impact on categorization
Valence	Varies by expression	No clear valence or low valence	Varies by expression
Arousal	High	Low	Varies by expression

processing is fundamental for directing our knowledge of the underlying mechanisms that support more sophisticated components of emotion processing (e.g., theory of mind).

Researchers test visual sensitivity to complex expressions using two main tasks. The most well known is the Reading the Mind in the Eyes Test (RMET; 8), which requires participants to visually inspect a static image of the eye region of an expressive face and select an appropriate label from four options to describe the expression. The version of this task that has been adapted for use with children excludes many of the expressions in the version of the task used with adults (e.g., desire, flirtatious; 9). Another task, the Cambridge Mindreading Face-Voice Battery (CAM), is structured much like the RMET, but instead of static images, presents participants with dynamic movies of actors expressing complex facial expressions and includes the entire face as well as the upper torso (10).[1]

Studies that use these paradigms to investigate adolescent-specific developmental changes in the ability to identify complex expressions have produced mixed results. In a study using the adult version of the RMET, adolescents (12–14 years) identified expressions less accurately than adults, even after controlling for verbal and working memory abilities (14). However, in another study that used the children's version of the RMET, 10- to 12-year-olds and adults performed comparably when identifying expressions, but 14- to 16-year-olds performed less accurately than both the younger adolescents and the adults (15). In a functional neuroimaging session with the same participants, several regions of the social brain of the young adolescents activated more strongly than those of the older adolescents and adults; but despite the lower accuracy in performance in the older adolescents, neural activation did not differ between the older adolescents and the adults (15). However, a recent study on the psychometric properties of the children's version of the RMET (16) revealed low internal consistency and low item-total correlations among a large group of adolescents, which suggests that interpreting performance differences on the children's version of the RMET in adolescents may be problematic. In short, the behavioral and neural evidence produced by studies using different versions of the RMET with adolescents is difficult to integrate into a consistent developmental story.

The most compelling and consistent evidence of adolescent-specific improvements in identifying complex expressions comes from two studies that used dynamic stimuli from the facial scale of the CAM (17, 18). In the first, researchers testing 12- to 23-year-olds found that age correlated highly with the ability to identify complex expressions even after controlling for differences in vocabulary and executive functioning (17). Following this study, the researchers evaluated age-related differences in neural responses to these complex expressions in 12- to 14-year-old girls and young women (18). While observing the dynamic expressions, brain regions critical for processing faces and inferring emotions were active in both adolescents and adults. However, adolescents' responses were larger than adults' in a ventromedial portion of the prefrontal cortex (vmPFC), a region involved in generating affective meaning (19). Together, these results suggest that the ability to identify complex expressions from dynamic facial expressions continues to improve through adolescence and may be mediated, in part, by changing activation in the vmPFC.

Finally, only one study measured the influence of puberty on the ability to process complex emotional expressions (14). Even though researchers identified age-related improvements in the adolescents' ability to recognize complex social expressions, they failed to detect an effect of pubertal status, which may have been related to the smaller number of girls in the prepubertal and pubertal groups, compared to the postpubertal group.

In summary, developmental changes in the ability to identify complex emotional expressions appear to depend on the paradigm used. The most robust behavioral and neural changes associated with adolescence have been measured using the CAM, while mixed results have been obtained using the RMET, particularly the children's version. Because there are too few studies, we cannot draw conclusions about the role of puberty in the development of the ability to perceive and categorize

[1]Researchers also evaluate complex emotion understanding by asking participants to identify verbally how the protagonist in a situational vignette is feeling (i.e., cartoon/verbal scenarios that exemplify a complex emotion but do not illustrate an emotional expression; 11–13). We have not included these studies in this article because these paradigms do not require participants to visually perceive or categorize facial expressions.

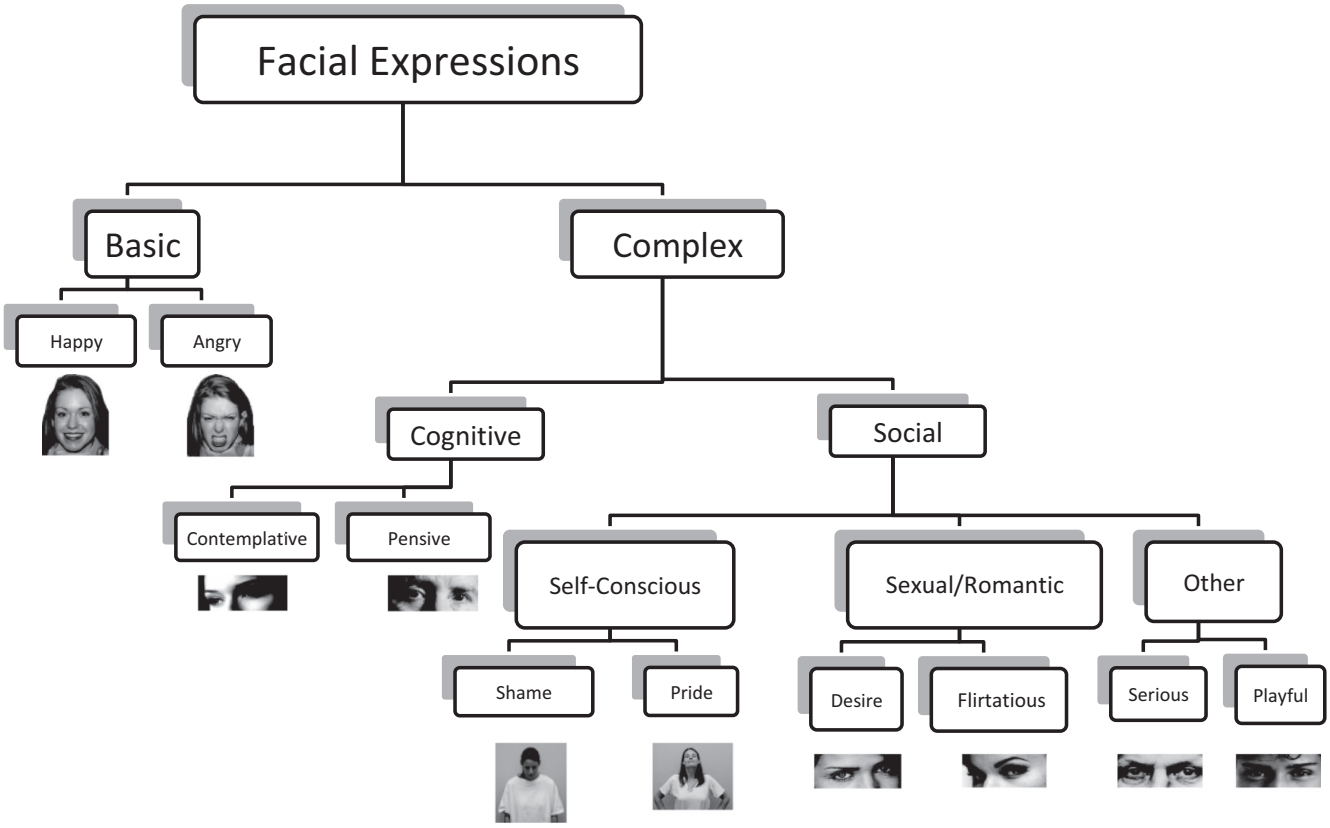

Figure 1. **The functional distinctions in signaling properties between basic and complex facial expressions and among complex cognitive, complex social, and other kinds of complex expressions. We propose that socially complex expressions might be further delineated to distinguish expressions that primarily communicate signals about romantic and sexual relationships (e.g., flirtatiousness, desire) from those that reflect self-consciousness. The stimuli used in this figure were taken from several databases (examples of basic expressions, Ref. 33; complex cognitive, complex other, and social sexual expressions, Ref. 8; and self-conscious expressions, Ref. 25).**

complex emotional expressions. In the following section, we suggest that conceptually meaningful differences between these tasks may explain these findings.

CONSIDERING DIFFERENT SUBCATEGORIES OF COMPLEX EXPRESSIONS

Unlike basic expressions, complex expressions are likely to be organized into subcategories of expressions that have different signaling properties. This perspective is functional in nature because it holds that expressions provide adaptive social signals that enable rapid appraisal and preparation to act (20). For example, complex expressions have been divided into the subcategories of complex *cognitive* and complex *social* expressions (3, 21). Complex cognitive expressions reflect inner thoughts (i.e., they do not necessarily result from interactions with people) and have low valence and low arousal (21; see Table 1 and Figure 1). In contrast, complex social expressions are elicited in specific social contexts, have a clear valence, and vary in arousal (21, 22; see Table 1 and Figure 1). This functional distinction is supported by studies reporting damage to the prefrontal cortex and amygdala (neural regions critical for processing emotions) that disproportionately impairs the ability to recognize and label complex *social*, but not complex *cognitive*, expressions (21, 22). Also, in adults, individual differences in amygdala volume predict recognition for complex *social*, but not *cognitive*, expressions (23).

Paradigms used to examine individuals' abilities to recognize complex expressions typically do not distinguish between complex cognitive and complex social expressions. For example, the expressions in the RMET include both complex cognitive and social expressions; however, approximately 80% of the trials include *cognitive* expressions. As a result, studies using the children's version of the RMET may primarily reflect age-related changes in sensitivity to *cognitive* expressions. In studies using this paradigm, particularly the children's version, which includes an even higher proportion of complex cognitive expressions, researchers have reported no age-related improvements in adolescents' recognition of complex expressions (15). In contrast, the CAM includes a higher proportion of trials requiring participants to identify complex social expressions (see Table 2).

Table 2
Complex Social Expressions by Proposed Category

Self-conscious	Social-Sexual	Other
Apologetic	Affectionate	Adoring
Approving	Attracted	Aggressive
Ashamed	Betrayed	Bitter
Embarrassed	Brokenhearted	Condescending
Guilty	Cheated	Defensive
Modest	Desirous	Gentle
Proud	Jealous	Hateful
Regretful	Lovesick	Judging

Note. Examples of expressions adapted from the Cambridge Mindreading Face-Voice Battery (10).

As a result, we predict that the ability to perceive and recognize complex cognitive expressions may mature in late childhood (based on findings from the children's version of the RMET), whereas the ability to process socially complex expressions may continue to develop into adolescence (based on findings with the CAM). We encourage researchers to evaluate this interpretation empirically.

Researchers will need to evaluate the claim that sensitivity to complex expressions may change during adolescence and may be influenced by pubertal hormones. We offer three proposals to guide work in this area based on the theory that age-appropriate social developmental tasks influence face-processing behavior (6), particularly during adolescence (4). Together, these proposals form a novel hypothesis about the influence of age and pubertal maturation on how we develop the ability to process complex expressions of emotion.

Proposal 1: Complex Social Expressions Include Subcategories of Expressions

We propose that further functional distinctions exist among kinds of complex social expressions (see Figure 1). For example, self-conscious expressions (e.g., pride, embarrassment) may be a subcategory of complex social expressions (24). These expressions facilitate behavioral adherence to moral standards and are evoked by self-reflection and self-evaluation (see Table 2). In addition to characteristic facial configurations, these emotions are typically expressed with characteristic body postures (e.g., arms in the air to signify pride; 25). We propose another subcategory of complex social expressions that we call social sexual expressions. These expressions provide signals about the status of romantic and sexual relationships by functioning with other nonverbal signals of interest and availability (e.g., primping) in human courtship behavior (26). For example, the coy smile (an expression combining a half-smile and lowered eyes) is a signal of flirtatiousness, and the eyebrow flash combined with a smile is a signal of sexual interest (27). The emotions of desire and sexual jealousy might also be communicated with particular expressions.

Proposal 2: Social Developmental Tasks Instigate Emerging Sensitivity to Expressions

Developmental tasks are salient criteria by which to judge adaptation to life (28). Success mastering developmental tasks in one ontogenetic period is probabilistically associated with mastery on subsequent developmental tasks (29). The social developmental tasks of childhood include learning societal propriety and expectations (e.g., stealing is prohibited), and beginning to understand the consequences for violating moral rules (28). In contrast, the social developmental tasks of adolescence involve acquiring independence from parental figures, forming confiding friendships with peers, and exploring age-appropriate romantic and sexual relationships (30). In previous work, we argued that these social developmental tasks likely influence the computational goals of the perceptual system, which are reflected in changing face processing behaviors like the perception and categorization of emotion expressions (6).

Using this framework, we predict that emerging perceptual sensitivity to subcategories of complex expressions may follow different developmental trajectories based on the relevance of each expression for accomplishing the social developmental tasks of childhood and adolescence. For example, given that self-conscious expressions provide signals relevant to learning social rules and norms, we predict that the ability to perceive and interpret these expressions emerges in early childhood (see Figure 2). Some findings support this prediction, indicating that young children can perceive and reliably distinguish self-conscious expressions like pride from basic expressions (31). We also expect that sensitivity to these self-conscious expressions will continue to improve through adolescence, given that the rules and standards relevant to adolescent behavior are evolving. In contrast, we predict that the ability to perceive and interpret social sexual expressions will not begin to emerge until adolescence (see Figure 2). Recall that the purported functional role of social sexual expressions is to provide signals about the status of romantic and sexual relationships. Exploring and engaging in these kinds of social relationships is not a primary developmental task until adolescence. We suggest that the social developmental task of learning about sexual and romantic relationships in adolescence fundamentally shapes the computational demands on the visual system (6), leading to a new perceptual sensitivity to social sexual expressions.

Proposal 3: Puberty Influences Perceptions of Complex Expressions

Finally, we propose that pubertal maturation specifically influences the development of complex expression processing. We hypothesize that puberty does not broadly affect the development of perceptual sensitivity to all complex emotional expressions. Instead, pubertal development likely shapes sensitivity to complex expressions that help accomplish the social developmental

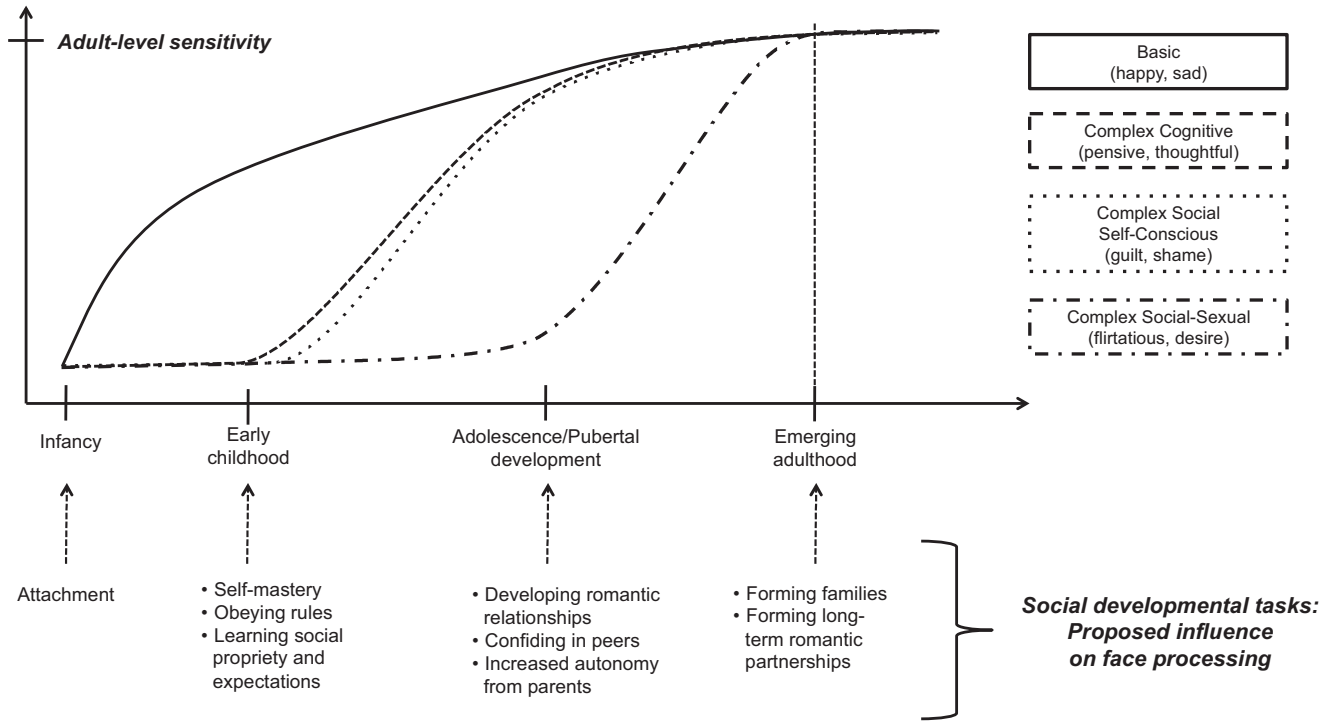

Figure 2. **Proposed developmental trajectories for emerging sensitivity to different kinds of facial expressions and the age-appropriate developmental tasks that influence the onset of these trajectories. In general, we predict that emerging sensitivity for each of these kinds of facial expressions is motivated by the need to successfully complete the age-appropriate social developmental tasks characteristic of each ontogenetic period. Specifically, in early childhood, the social developmental tasks of learning to obey rules and understanding social consequences for violating moral rules are hypothesized to influence the emergence of visual sensitivity to the *self-conscious expressions*. However, sensitivity to these expressions will continue to develop into and beyond adolescence given that new behaviors emerge that are subject to new rules that must be learned as well. In contrast, the emergence of developmental sensitivity to complex *social sexual expressions* will not occur until adolescence, given the social developmental tasks of exploring romantic relationships with peers do not emerge until this ontogenetic period.**

tasks that are also influenced by pubertal development. More specifically, pubertal development is likely to influence, and may instigate, adolescents' motivation to master new social developmental tasks, such as developing confiding friendships and romantic and sexual relationships with peers. In turn, progress toward these developmental tasks will require new social-affective components of face processing to emerge, including visuoperceptual sensitivity to social sexual expressions and expressions signaling violations of loyalty (e.g., contempt) and deceitful behavior (e.g., insincerity), given their role in providing signals about confiding peer friendships.

For example, we predict that prior to pubertal development, the visual systems of young children and young adolescents (compared with pubertal or sexually mature individuals) require much more perceptual information to detect social sexual expressions than to detect basic or self-conscious expressions. In addition, we do not expect that prepubescent children can reliably categorize social sexual expressions differently from other kinds of expressions. We predict that prepubescent children are not likely to be able to distinguish happiness and coy smiles into different categories of expressions, whereas we expect that pubescent adolescents do begin to separate these expressions into different categories.

LOOKING AHEAD

We have provided a novel theoretical framework for research investigating the role of adolescence and pubertal development in developmental changes in the processing of complex emotional expressions. We conclude by offering several recommendations for researchers working in this field.

First, given that the social developmental tasks of adolescence are focused primarily on peer relationships, we encourage researchers to evaluate potential differences in sensitivity to expressions generated by age-matched peers versus those generated by adults. We expect that emerging sensitivity to these complex social expressions may be optimized for peers' faces.

Second, work will need to dissociate the covarying influences of puberty and age on changing sensitivity to facial expressions. One useful design involves taking advantage of the differences in timing of pubertal development within a narrow age range (32). We suggest that study designs be optimized to assess behavioral and neural outcomes in adolescents who are matched on age but vary in pubertal status (e.g., early developers and late developers who are both 11 years old) or vice versa.

Third, longitudinal work will be essential for mapping the full developmental trajectories of sensitivity to these different kinds

of complex emotional expressions and evaluating the extent to which these trajectories may be nonlinear. This work will help us understand the emergence (i.e., onset) of sensitivity to particular emotional expressions versus the maximum influence (i.e., peak) of such sensitivity on behavior. In addition, longitudinal work will offer the opportunity to observe potential interactions between the trajectories of different categories of expressions.

Finally, we encourage researchers to evaluate the relation among progress toward the social developmental tasks of adolescence, pubertal development, and the emergence of perceptual sensitivity to various categories of complex social expressions to test the predictions we have articulated.

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