Vol. 16, No. 25 • December 10, 1996

Directions in Psychiatry

VOLUME • 16

LESSON • 25

PHYSIOLOGIC EFFECTS OF THE SMILE

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EDITOR'S NOTE

More than 100 years ago, the French neurologist G.B. Duchenne observed that there was more than one way to smile, but only one type of smile accompanied positive emotions. Such a smile was expressed on the face by the combined contraction of the *zygomatic major* muscle, causing an upward pulling of the lip corners, and the *orbicularis oculi*, causing the skin above and below the eye to be pulled in towards the eyeballs. Recent research tends to confirm Duchenne's findings, with the additional observation that only the *pars lateralis* portion of the *orbicularis oculi* is active during enjoyment. Moreover, the movements of the *zygomatic major* muscle are smooth, symmetrical, short-lived, and well synchronized with the action of the *orbicularis oculi*. In this lesson, the authors explore the neuroanatomical and neurophysiological issues that may be involved with the smile.

For clinicians, smiles can be very important nonverbal clues to various emotional states. For example, in a depressed patient, a genuine Duchenne smile may indicate improvement, whereas a smile without the *Duchenne marker* may reflect negative emotions and feelings such as embarrassment or disdain, dissembling, or an attempt to conceal suicidal ideation and intent. From the patient's point of view, the psychiatrist's type of smile, or lack thereof, must make its own statement as well.

If a smile with the Duchenne marker is associated with enjoyment and if individuals who smile this way are perceived as more sincere, honest, friendly, and approachable, would instruction as to how to cultivate such a smile have a positive influence on a person's feeling state as well as on his or her interpersonal relationships?

Introduction

"Smile and you'll feel better" is an instruction most parents have issued to their children at some point in their lives. **Parents make this suggestion because they know that the smile is the facial expression for the positive emotions, such as amusement, sensory pleasure, relief, and pride in achievement, that make life worth living. Yet the smile can be enigmatic; although it is the expression for the positive emotions, it also can be used to express politeness and uncertainty, as well as to mask negative emotions.**[1] From a clinical viewpoint, these many guises of a smile present a problem: when is the smile an expression of a positive, felt emotion, and when is it not? Does making a smile have any actual effect on a patient's feelings? Imagine a suicidal patient who smiles and declares that he or she feels well enough to be released from treatment. Does this smile mean that they are feeling happy and hence are recovering? Or, is this smile masking negative emotion, and thus the patient is still suicidal? Moreover, what effect does the act of smiling have on this patient; by attempting to smile, might the patient feel better? According to our research, the answer to these questions depends upon the type of smile shown by the patient.

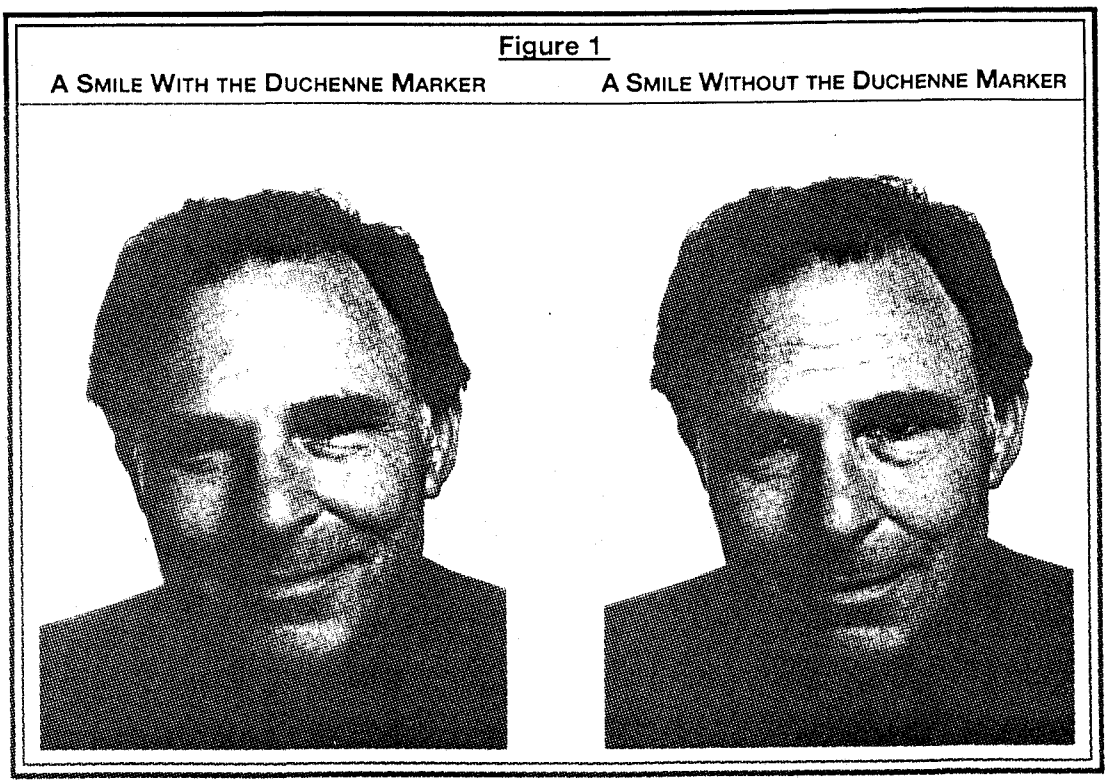
The History of Smile Research

A necessary and sufficient characteristic of any smile is an upward pulling of the lip corners; this upward pulling is caused by the action of the *zygomatic major* muscle. This action is recognized and labeled as positive emotion, such as happiness or enjoyment, in every culture in which it has been studied. This includes cultures with limited contact with Westerners such as the South Fore of Papua New Guinea and the Dani of West Iran,[1] unschooled Ethiopians,[2] and the Minangkabau of Sumatra.[3] **Given the universal agreement that someone who is smiling is feeling a positive emotion, one would expect that the function of the smile must be to express facially what is happening physiologically during positive emotion.**

Yet more than 100 years ago in 1862, the French neurologist G.B. Duchenne noted that there was more than one way to smile; of these, only one type of smile accompanied the positive emotions. Duchenne[4] wrote, "The emotion of frank joy is expressed on the face by the combined contraction of the *zygomatic major* muscle, and the *orbicularis oculi.* The first obeys the will but the second is only put into play by the sweet emotions of the soul. . . ." Darwin[5] discussed this distinction in his book *The Expression of the Emotions in Animals and Man.* Although he mentioned the differences between these types of smiles were barely noticeable, he noted that most people to whom he showed photos of these smiles were able to identify easily which smile was a real expression of positive emotion and which one was not. These different smiles are shown in Figure 1.

Much of the behavioral science research that followed Darwin's book failed to note this distinction and may have suffered on account of this oversight. Empirical work by Landis,[6] who labeled smiles on the basis of the presence of *zygomatic major* action only, showed that the smile was the most frequent facial expression in 16 different situations ranging from listening to popular music to decapitating a live rat. Landis reported that people smiled regardless of whether they reported feeling anger, disgust, exasperation, revulsion, surprise, or sexual excitement; he eventually concluded that the smile was a misleading and meaningless indicator of any particular inner state or emotion.

Figure 1



Other experimental psychologists, using the same smile criterion as Landis, observed that people smiled when they were embarrassed,[7] sad,[8] or simply in the presence of others.[9] Klineberg[8] concluded, "Not only may joy be expressed without a smile, but in addition the smile may be used in a variety of situations in a manner quite different from what appears to be its original significance. Even in our own society, we know that a smile may mean contempt, incredulity, affection, and serve also as part of a purely social greeting devoid of emotional significance." Other influential reviews of the experimental psychology literature echoed this conclusion.[10–12]

Cultural anthropologists supported the conclusions of the experimental psychologists by observing that humans from different cultures smiled in situations involving both negative and positive emotions.[13–15] Africans were described as people who smile to express not only amusement but surprise, wonder, embarrassment, and discomfort.[14] These anthropologists concluded that the meaning of the smile was culturally determined, that, in general, no facial expressions for different emotions were universal, and that, in particular, no specific facial expression was specific for positive emotion.

It appears the reason these researchers concluded that smiles do not represent positive emotional states was that they grouped all smiles into a singular category. Thus, by failing to distinguish between smiles with and without *orbicularis oculi* action, they could neither support nor refute Duchenne's original observation of a link between one type of smile and positive emotion.

Current Research and Terminology

Only in the last 15 years have Ekman and Friesen[16] and their colleagues rediscovered, validated, elaborated, and sharpened Duchenne's observation. Duchenne did not distinguish between actions of different sections of the *orbicularis oculi* muscle; however, Ekman and associates[17] noted that most of their sample could deliberately flex the *pars medialis* portion of their *orbicularis oculi* muscles, but only about 20% of these people could deliberately flex the *pars lateralis* portion of their *orbicularis oculi* muscles. Ekman and coworkers[18] further noted that it is only this *pars lateralis* portion of the *orbicularis oculi* that is active during enjoyment. **This led Ekman[1] to define smiles that involved the *orbicularis oculi* and *pars lateralis* in conjunction with the *zygomatic major* as "enjoyment smiles"; furthermore, he proposed that the *orbicularis oculi* and *pars lateralis* action be called the *Duchenne marker* of an enjoyment smile, in honor of Duchenne's work.**

Origins of the Enjoyment Smile

If an enjoyment smile is an expression of positive emotion, one would expect a neuroanatomical link between the facial muscles and an emotional center in the brain. **In fact, there appear to be two distinct neural pathways that mediate facial expressions, each one originating in a different area of the brain: one pathway for voluntary, willful facial actions and a second for involuntary, emotional facial actions.**[19–21] **The voluntary facial movements originate in the brain's cortical motor strip and arrive at the face via the pyramidal motor system. Involuntary facial movements, such as those involved in an emotional expression, arise mainly from subcortical nuclei, similar to those associated with emotion, and arrive at the face via the extrapyramidal motor system.** This dual pathway hypothesis is supported by clinical reports of patients who consciously cannot retract both sides of their *zygomatic major* because of a lesion in the cortical motor strip contralateral to the affected side; these same patients can and do spontaneously retract both sides when they find something humorous.[22] Similarly, patients with lesions of the subcortical nuclei, such as the basal ganglia, have difficulty showing spontaneous, emotional facial expressions; however, these same patients are able to move their facial muscles on command.[23] **These facial action observations are so reliable that they serve as diagnostic criteria for pyramidal and extrapyramidal lesions.**[24]

Not only do voluntary and involuntary facial actions differ by neural pathway, but the actions mediated by these pathways manifest themselves differently. In a normal person, voluntary pyramidal motor system-based movements are limited solely by individual effort. A person consciously can move a facial muscle quickly or slowly and hold that action for a brief or long period of time, depending upon the dictates of the circumstance and individual endurance. However, extrapyramidal motor system-based facial actions are characterized by synchronized, smooth, symmetrical, consistent, and reflexlike or ballisticlike actions of the component facial muscles.[25] The individual has less deliberate control of these facial actions.

Given this neuroanatomical foundation, plus Duchenne's observation and their own observations of a large data set, Ekman and Friesen[16] predicted that the *orbicularis oculi* and *zygomatic major* configuration observed by Duchenne would be but one of several morphologic and dynamic markers that would distinguish between smiles that are shown with positive emotions and smiles that are shown for other reasons. **Specifically, they predicted that enjoyment smiles should feature two morphologic markers:** the action of the *orbicularis oculi* and *pars lateralis* in conjunction with the *zygomatic major* (i.e., the modification of Duchenne's observation or the Duchenne marker) and the symmetrical action of the *zygomatic major* on both sides of the face (i.e., symmetry marker). **Consistent with the dynamics of extrapyramidally driven facial actions, Ekman and Friesen[16] predicted three dynamic markers:**

1. Onset, apex, offset, and overall *zygomatic major* actions that are smooth and not as irregular as in other types of smiles (i.e., smoothness marker)
2. A relatively limited and consistent overall duration of *zygomatic major* action from smile to smile, in which enjoyment smiles are not as long or as short as other smiles, usually

between 1/2 and 5 seconds (i.e., duration marker)

3 Synchronization of action between the *zygomatic major* and *orbicularis oculi*, in which they both reach the point of maximal contraction, or apex, at approximately the same time (i.e., synchrony marker)

The Evidence for the Enjoyment Smile

A handful of studies has verified the relationship of the symmetry,[26] duration,[27,28] smoothness,[27,28] and synchrony markers with positive emotions. However, the most studied, most replicated, best documented marker that has shown the most convergent validity across subject groups and social conditions has been the Duchenne marker.[29]

Laboratory research has shown that the number of smiles with the Duchenne marker increases when subjects watch films designed to elicit positive emotion and decreases when subjects feign positive emotion while viewing films designed to elicit negative emotion.[18] The total number of all smiles considered together did not predict which film the subject was watching. Other research has shown that not only did the frequency of the Duchenne marked smiles—but not other smiles—predict when a subject was watching a film designed to elicit positive emotion but that the frequency of the Duchenne marked smiles predicted which of the two positive-emotion films subjects reported enjoying more.[30]

In psychotherapy settings, smiles with the Duchenne marker occur in greater frequency in depressed patients' discharge interviews compared with their admission interviews.[31] When psychotherapy patients are judged to have improved, they show a corresponding increase in smiles with the Duchenne marker as opposed to smiles without this marker.[32] Schizophrenic patients show fewer Duchenne-marked smiles than do normal individuals.[33] Mothers who were receiving counseling for their abusive tendencies showed fewer smiles with the Duchenne marker to their more difficult children than did nonabusive mothers to their difficult children.[34] Taken together, these studies show that only smiles with the Duchenne marker predict self-reports of positive emotion or positive psychotherapeutic outcomes; all types of smiles considered together do not. **Thus, had the Duchenne marker been ignored in these studies, and all smiles treated as a singular class of behavior, these results would have replicated the findings of Landis, the experimental psychologists, and the anthropologists that the smile was not related to positive emotions.**

Relationship to Physiology of Emotion

In contrast to previous models of emotion,[35] evidence is mounting that certain "basic" emotions, such as anger, fear, disgust, sadness, and enjoyment, have their own specific pattern of autonomic nervous system (ANS) activity.[3,36,37] These specific ANS patterns were produced regardless of whether emotions were elicited by asking subjects to recall and reexperience emotional situations, by showing them film clips designed to elicit certain emotions, or by asking them to pose the facial expression associated with each emotion.

Research also has found that specific emotions have specific central nervous system (CNS) patterns of hemispheric brain activation, as measured by electroencephalography (EEG). In particular, experimentally aroused, approach-related positive emotion has been associated with relatively greater left-sided anterior activation, whereas withdrawal-related negative emotion has been associated with relatively greater right-sided anterior activation.[38–40]

Only recently has research shown that smiles with the Duchenne marker are linked to the CNS physiology of approach-related positive emotion, whereas smiles without the Duchenne marker are not. Thus, when subjects' electroencephalograms are monitored as they watch emotion-inducing films, only the smiles with the Duchenne marker—but not other smiles—correlate with their self-reports of enjoyment and produce a relatively greater left hemisphere brain activation.[30,41] This same pattern of CNS activity for smiles with the Duchenne marker was found in 10-month-old infants when they showed more Duchenne marked smiles in response to the approach of their mothers than they showed to the approach of a stranger.[42]

Although the researchers had shown a relationship between spontaneous, involuntary expressions of smiles with the Duchenne marker and relatively greater left-sided anterior activation,[30,41] they could not directly test Duchenne's idea because no study had manipulated experimentally the presence or absence of the Duchenne marker in smiles. Recently Ekman and Davidson[43] tested this idea by asking subjects to voluntarily generate smiles with and without the Duchenne marker to determine if deliberate smiles would produce the same electroencephalographic pattern of CNS activity that was found in spontaneous smiles.

As part of a larger experiment, they asked 14 subjects to pose a smile with and without the Duchenne marker (along with other facial expressions). A coach, who could observe and instruct the subject from a remote location, instructed subjects in one trial to first "raise your cheeks," and then "part your lips and let your lip corners come up," the Duchenne marker instruction. In a different trial (the order of these trials were varied across subjects), subjects were instructed only to "part your lips and let your lip corners come up," another smile instruction. Once the coach determined that the subject was showing the instructed expression, the subject was asked to hold that expression for 20 seconds.

The subjects' electroencephalographic activity was measured from their left and right mid-frontal (F3, F4), lateral frontal (F7, F8), anterior temporal (T3, T4), central (C3, C4), posterior temporal (T5, T6), parietal (P3, P4), and occipital (O1, O2) regions as they held these expressions. **After removing all artifacts and other**

sources of noise, Ekman and Davidson[43] found that posing smiles with the Duchenne marker caused subjects to show significantly greater activation of the left side of the lateral frontal, mid-frontal, anterior temporal, and central anterior scalp regions—almost exactly the same pattern found in spontaneous displays of smiles with the Duchenne-marker. Finally, Ekman and Davidson determined that this pattern was not because of possible confounds such as the number of facial muscles needed to make each expression or because of the perceived difficulty of posing the facial expression.

Thus, Ekman and Davidson[43] were able to show that one could produce brain activation patterns of positive emotion by simply asking subjects to pose smiles with the Duchenne-marker. These findings, combined with the findings derived from subjects with spontaneous Duchenne-marked smiles, strongly suggests that at least some of this brain activity pattern is specific to approach-related positive emotion and not dependent upon the method used to elicit the emotion. **Although it is generally accepted that emotions happen to people, these results suggest that it may be possible to generate some of these physiological changes that occur with spontaneous smiles by deliberately making a smile with the Duchenne marker.**

Psychiatric Implications

This work has two clear implications for the clinician. First, it suggests that clinicians should learn how to visually distinguish between smiles with and without the Duchenne marker to establish their patients' current emotional state. Second, it suggests that a clinician may be able to elicit some of the physiological changes associated with the positive emotions by just asking patients to pose a smile with the Duchenne marker. **However, to accomplish either goal, a clinician must first know the specific appearance changes in a smile that occur as a result of the Duchenne marker.**

How to Recognize the Duchenne Marker

Compared with the other four markers of an enjoyment smile, the Duchenne marker most readily lends itself to accurate, real-time visual recognition. Identifying the other four markers involves using more sophisticated videotaped analysis, electromyography, or other more time-intensive technologies.[29]

Again examine Figure 1. **Note that the action of the *orbicularis oculi* and *pars lateralis* combination in the Duchenne marker causes the skin above and below the eye to be pulled in towards the eyeball; this action causes the following changes in appearance:** (a) the cheeks are pulled up, (b) the skin below the eye may bag or bulge, (c) the lower eyelid moves up, (d) crow's feet wrinkles may appear at the outer corner of the eye socket, (e) the skin above the eye is pulled slightly down and inwards, and (f) the eyebrows move down very slightly. In contrast, a smile without the Duchenne marker features the same movement of the lip corners as the enjoyment smile but does not involve the changes caused from the muscles around the eyes.[44]

There is one complication: with a very big or broad smile that does not have the Duchenne marker, the strong contraction of the *zygomatic major* will produce many of the changes produced by the action of the *orbicularis oculi*, simulating a smile with the Duchenne marker. In a big smile, clues (a) through (d) will be present regardless of whether the Duchenne marker is present. In a broad or large smile one must look only for clues (e) and (f), which appear only with the Duchenne marker. **Thus, the clues that are more diagnostic are dependent on whether the smile is slight or broad.**

The main disadvantage of relying upon the Duchenne marker as the sole criterion for positive emotion is that up to 20% of the population consciously can contract the lateral portion of their *orbicularis oculi* muscles and, thus, are capable of producing a false Duchenne marker.[17] (But might posing this false marker in fact make them feel more positive?) We also note that smiles without the Duchenne marker do not necessarily connote nonpositive emotions; it may be possible that *zygomatic major* action without *orbicularis oculi* may signal low or weak levels of enjoyment.[45] Further research will help elucidate this possibility.

To date, no one has determined if a clinician can spot these different smiles in a face-to-face, real-time encounter. However, one study approximated these conditions by showing groups of observers videotaped clips of women who spontaneously showed smiles with and without the Duchenne marker (of equal *zygomatic major* intensity). Both types of smiles occurred in response to films designed to elicit positive emotion. This study found that observers were able to distinguish between smiles that had the Duchenne marker and smiles that did not—at significantly better-than-chance guessing rates.[27] Interestingly, these observers were most accurate in making this distinction when they judged smiles of low *zygomatic major* intensity because lowered *zygomatic major* activity increased the salience of *orbicularis oculi* action.

The presence or absence of the Duchenne marker also caused observers to have different impressions of the same person. In this study, observers were shown the same videotapes, as in the aforementioned experiment, and then asked simply to rate the personality characteristics of each stimulus subject. **The results showed that each stimulus subject was rated as acting and feeling significantly more pleasant, outgoing, likable, sincere, honest, and genuine,** (i.e., generally rated more positive) **when they showed a smile with the Duchenne marker as opposed to the smile they showed with the same *zygomatic major* intensity but without the Duchenne marker.[27]**

These judgment studies suggest that it is possible to identify the Duchenne marker in real time. The utility of making the distinction between smiles with and without the Duchenne marker in diagnosing, monitoring, and tracking the effects of treatment for various clinical disorders has already been demonstrated in the

studies cited earlier. **We would recommend that any clinician who is interested in being able to make this distinction learn the Facial Action Coding System (FACS).[44] FACS is a system for measuring reliably all visible facial actions; it involves approximately 100 hours of study, and includes a final test of proficiency.** Those interested can obtain information on FACS by writing Professor Ekman at the University of California Medical School in San Francisco.

How to Manipulate the Duchenne Marker

The second implication of this smile research on clinical practice is that one can produce the physiology of positive emotions by asking subjects to pose a smile with the Duchenne marker. One of the difficult aspects of emotions is that they are unbidden and difficult to control. Many affective disorders are characterized by this problem—unrelenting sadness in depression, or fear in generalized anxiety disorder. One can imagine the utility of a simple, drug-free technique that would enable a clinician to assist patients to regulate their moods more effectively (e.g., to help stabilize a depressed patient over the typical 2–3-week period when they are being titrated for a tricyclic antidepressant or fluoxetine [Prozac]).

The instructions for making the Duchenne marker of a smile have been described: instruct patients to "raise your cheeks," and then "part your lips and let your lip corners come up."[43] It may be easier if you first ask your patients to squint as hard as they can, or close their eyes as tightly as they can. Tell them they are using the correct muscle when they do that; now you want them to contract that same muscle but less strongly, so their eyes stay open. Then, add in a smile. The patient should hold the pose for at least 20 seconds. It is important that the person coaching the patient ensure that the smile is posed properly; FACS-trained individuals are best able to do this because they will be more familiar with the criteria for Duchenne's marker described earlier.

No research on the use of this technique as a therapeutic tool has been conducted. We do not know how long lasting these effects are. We do not know whether they will even work on a clinical population. We do not know if they will work with patients on medication. We do not know if this technique may exacerbate their emotional problem by causing mood swings. We do not know whether this technique can overcome the powerful emotions felt by patients who are depressed or anxious. However, we do know that the patient would have to pose the Duchenne marker accurately. We do know that not all patients can deliberately contract their *orbicularis oculi* and *pars lateralis*. We do know that it appears this technique would treat only the symptom and not the problem that may underlie or cause the negative emotions in the first place. **Thus, much research remains to be done, both inside and outside the clinic, before hailing this as an effective therapeutic technique.**

Conclusion

Not all smiles are created equal. One type of smile in particular—the enjoyment smile, as identified by the Duchenne marker—seems to differ from other types of smiles on a number of dimensions. First, the enjoyment smile is related to the internal emotional state of the individual in a way that other smiles are not. This is true at the level of self-report ratings,[30] behavioral observations,[31,42] or CNS measurement.[30,41,43] Second, the enjoyment smile differs in both form and motion from other types of smiles.[29] Third, enjoyment smiles have a different social signal than other smiles.[27] Fourth, posing an enjoyment smile can produce the physiology of positive emotions.[43]

It seems reasonable to conclude that the enjoyment smile is lawful behavior, and that its features operate more independently of context than other types of smiles, as Ekman and Friesen[16] had predicted. Moreover, the critical marker of the enjoyment smile—the Duchenne marker—can be seen quite readily with the naked eye, which allows clinicians to use this marker to identify more accurately the emotional state of their patients. By instructing patients to pose the Duchenne marker, clinicians may be able to produce positive emotions from their patients. However, using this technique therapeutically has not been studied, so caution is recommended.

Finally, our research argues that clinicians can become more effective by observing these subtle differences in the facial expressions of their patients, and knowing how to use them to improve the monitoring and delivery of their treatment. **When a depressed patient smiles and claims to feel better, a clinician should add to his or her clinical repertoire the observance and identification of the Duchenne marker; moreover, the clinician may be able to ensure that the patient is actually feeling happier by asking for a smile with the Duchenne marker. At the very least, clinicians who gain any additional sensitivity to accurate clues to the emotional state of patients can only improve the course of their treatment.**

*As an organization accredited for continuing medical education, St. Vincent's Hospital and Medical Center of New York certifies that when these continuing medical education materials (*Directions in Psychiatry*) are used as directed, they meet the criteria for 30 hours of credit in Category 1 of the Physician's Recognition Award of the American Medical Association.*

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QUESTIONS BASED ON THIS LESSON

These questions must be answered for CME credit. Please mark your answers on the response form.

73. Which of the following statements is correct:

A. Ekman, Roper, and Hager found that most subjects could deliberately flex the *pars lateralis* portion of their *orbicularis oculi* muscles, but only about 20% could flex the *pars medialis* portion.

B. Ekman defined smiles consisting of the *orbicularis oculi, pars lateralis* in conjunction with the *zygomatic major* as enjoyment smiles.

C. Involuntary facial movements originate in the brain's cortical motor strip and arrive at the face via the pyramidal motor system.

D. Voluntary facial movements, such as those involved in emotional expression, arise mainly from subcortical nuclei and arrive at the face via the extrapyramidal motor system.

74. In psychotherapy settings:

A. Smiles with the Duchenne marker occur less frequently in depressed patients' discharge interviews compared with their admission interviews.

B. Mothers receiving counseling for their abusive tendencies showed fewer smiles with the Duchenne marker to their more difficult children than did nonabusive mothers to their difficult children.

C. Schizophrenic patients show more Duchenne marker smiles than smiles without this marker.

D. All of the above are true.

75. In experimental settings, smiles with the Duchenne marker and a simultaneous increase in left-hemispheric brain activation were noted in:

A. 10-month-old infants in response to the approach of strangers

B. Subjects with right hemispheric brain damage

C. Patients with Alzheimer's disease

D. Movie viewers reporting episodes of enjoyment

QUESTION BASED ON A PREVIOUS LESSON

Which of the following statements is correct?

A. The diagnosis of attention deficit hyperactivity disorder (ADHD) in adolescents does not include impulsivity as a characteristic.

B. Relatives of people with ADHD have higher morbidity risks for anxiety disorders.

C. High CSF 5-HT is found among aggressive boys with ADHD.

Answer: B

QUESTION BASED ON A FUTURE LESSON

Neuroimaging studies are indicated in patients with acute mental status changes who:

A. Are less than fifty years old

B. Have no history of head trauma leading to loss of consciousness or neurological symptoms

C. Present new onset delirium or dementia of unknown etiology

D. Manifest recurrent episodes of psychosis over a five-year time span or more associated with failure to take maintenance antipsychotic medications on a regular basis

Answer: C

These questions are for self-assessment only. Answers appear below.

Directions in Psychiatry (ISSN 0891-3870) is published biweekly with a year-end index issue (27 issues per year) for $357 per year by The Hatherleigh Company, Ltd., 1114 First Avenue, Suite 500, New York, NY 10021-8325.

Periodical postage paid at New York, NY, and additional mailing offices. POSTMASTER: Send address changes to *Directions in Psychiatry*, 1114 First Avenue, Suite 500, New York NY 10021-8325.