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Age Estimation of Faces: A Review

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SUMMARY

Accurate age estimation is important in a variety of settings, particularly those in which age is a condition for access to a product such as alcohol or tobacco. The current paper reviews data on the estimation of age, focusing on changes that occur to the ageing face, methodology and findings. The accumulated data suggest that age estimation of unfamiliar faces can be quite accurate, is sensitive to cues at the local and global level and may vary on the basis of group membership. Potential directions for future research are highlighted and findings are discussed with respect to their implications for policies regarding the solicitation of age identification. Copyright © 2008 John Wiley & Sons, Ltd.

People are often called upon to estimate the age of individuals. This may take the form of assessing the age distribution in one's class, the age of an individual suspect from a crime scene, or tasks such as attempting to determine eligibility (to buy a product or access a service) on the basis of age. Nowhere is the importance of accurate age estimation more apparent than for individuals such as clerks or bartenders who are charged with limiting access to alcohol or tobacco. Several field studies (e.g. Jason, Pokorny, Sherk, Helzing, & Rebus, 2003; Merrill, Stanford, Lindsay, & Neiger, 2000; Willner & Rowe, 2001) have solicited age judgements from employees of stores which sell alcohol and/or tobacco. For example, Willner and Rowe (2001) asked servers in Wales (where the legal age for the purchase of alcohol is 18) to judge the age of 16-year-old boys and girls (among other age groups) from photographs. Results showed that for photographs of 16-year olds, 38% of boys and 56% of girls were judged to be of legal drinking age (i.e. 18 years of age or older). Some of the same individuals that were pictured also operated as field agents for the researchers and attempted to purchase alcohol. Strikingly, these agents were able to purchase alcohol without challenge for age identification 60 and 70% of the time, for boys and girls, respectively. Based on these data, Willner and Rowe (2001, p. 382) concluded that '…misperceptions of young people's ages may play a significant role in sales of alcohol to underage customers'. Similar investigations have reported that clerks overestimate the age of minors near the age of eligibility for purchase of alcohol or tobacco approximately one-third of the time (Jason et al., 2003; Merrill et al., 2000). In an effort to combat these problems, Tennessee has recently mandated that all individuals be asked for identification, regardless of apparent age (Johnson, 2007).[1]

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[1]The law was initiated on 1 July 2007, and is subject to renewal in 2008.

Such issues beg the question of what research has revealed about the accuracy of age estimation. The literature on this topic is diverse and scattered, ranging from understanding mathematical transformations that capture growth (e.g. Pittenger & Shaw, 1975a; Todd & Mark, 1981), to the relation between perceived age and characteristics such as attractiveness (Henss, 1991) and kindness (e.g. McArthur & Apatow, 1983–1984), to more systematic investigations of factors that influence perceived age (e.g. Burt & Perrett, 1995; George & Hole, 1995, 1998, 2000). Presently, no comprehensive review of the age-estimation literature exists that links these highly related issues. The current paper attempts such a review and is divided into three sections. The first section briefly describes the physical/biological changes that occur to the ageing face, providing the physical cues for judgements of age. The second section examines the general findings of the age-estimation literature and details those factors that influence age estimates, such as the amount and type of information available in the face and group characteristics (e.g. judging the age of in-group *vs.* out-group individuals). The review concludes by noting several lingering issues and gaps in the literature, directions for future research, as well as recommendations for public policy.

THE AGEING OF THE FACE

Ageing has a number of dramatic effects on the face (see Enlow, 1982; Berry & McArthur, 1986, for reviews). During the stage of growth, the face undergoes what has been characterized as a 'remodelling' (Enlow, 1982). The newborn's head appears wide and vertically short due to a large neurocranium that must house a brain that is more developed than the remainder of the face and a relatively small, pug-like nose and jaw bones that have yet to grow fully. The eyes of a young child appear large relative to the face. However, as the nasal and jaw regions grow the appearance of the eyes becomes proportionally smaller.[2] Likewise, the forehead of a child appears large and high because the facial features below it have not fully grown. The forehead continues to grow (and becomes more sloping) but appears more proportionate as the rest of the face develops. Development is also characterized by the growth of the nose and nasal bridge (necessary to accommodate a progressively larger lung capacity) into a more angular shape. If seen as a series of 'moving' features, the product of development is a movement of features 'up' a face that becomes more elongated with time, particularly with the growth of the jaw bones.

Even with the cessation of growth at approximately 20 years of age, the face continues to change. Nose and ear cartilage keep growing, progressively enlarging the size of those features. The skin also undergoes an array of changes in texture and appearance. During childhood, the skin is soft, firm and smoother than that of adults (Berry & McArthur, 1986). By middle age, the connective tissue anchoring the skin to the bones of the face begins to change, leading to drooping or sagging that is exacerbated by a loss of adipose (fatty) tissue. There is also a decrease in the amount of water-proteins in the skin which, among other factors, results in dehydration that encourages wrinkling. The onset of wrinkling is typically in the 30s or 40s (often along the 'smile line' apparent when one grins) and by '. . .advanced old age, a person's face can become an expansive carpet of noble ripples and

[2]In fact, adults who have large, round eyes, among other features (e.g. a small nose, a less prominent chin), are perceived to have 'baby-faces'. Several studies have shown that adults with these features are perceived as younger than adults of the same age who possess less 'babyish' features (e.g. Berry & McArthur, 1985; McArthur & Apatow, 1983–1984; see Berry & McArthur, 1986, for a review).

lines' (Enlow, 1982, p. 11). Along with wrinkling, hair becomes grey and of a lesser quantity, edentation (the loss of teeth) may occur, eyebrows become thicker and the relative size of the eyes and shape of the lips changes. Thus, given the myriad of changes that age brings to the face, age estimation may be sensitive to any of a number of cues that are indicative of age (*cf.* George, Hole, & Scaife, 2000; Burt & Perrett, 1995). In the next section, I detail the general findings from the literature on age estimation and discuss those cues that influence age estimates.

AGE-ESTIMATION: METHODOLOGY AND FINDINGS

The most common method of studying age estimation is probably also the most intuitive: participants simply see a photograph of an individual's faces and make an estimate of the age of the individual pictured (be it by rounding to the next year or including years and months in the estimate). Other methodologies that measure age perception have been less frequently employed. For example, several researchers have required participants to categorize rapidly presented photographs as those of a younger or older person (e.g. Bruyer, Mejias, & Doublet, 2007) or to group faces into categories, such as young, middle-aged or older adults (Anastasi & Rhodes, 2005, 2006). Sorting tasks have also been used, requiring participants to rank photographs from the youngest to the oldest individual or *vice versa* (e.g. Markey, 1934; Pittenger & Shaw, 1975b), though this methodology has been more frequently employed with children (e.g. Britton & Britton, 1969; Edwards, 1984). The child literature also includes a number of studies using discrimination tasks in which participants are simply asked to name which of two individuals is the oldest (e.g. George et al., 2000; Looft, 1971) or youngest (Gross, 2004).

The basic question to be asked regards the accuracy of age estimates. When examining only data reported for faces that have not been manipulated or transformed in any way, one finds that age estimates can be fairly accurate when judging a diversity of age groups. For example, Burt and Perrett (1995) had younger and older adults make age estimates for colour photographs of individuals aged 20 to 54. Results showed that estimated age deviated only slightly (2.39 years) from the actual ages of the individuals in the photographs. George and Hole (2000) and Sörqvist and Eriksson (2007) have reported similar levels of accuracy, with deviations from actual ages on the order of approximately 3 and 4 years, respectively. This coheres with a variety of other reports of minor deviations between actual and estimated age (e.g. George & Hole, 1995, 1998; Henss, 1991; Pittenger & Shaw, 1975b),[3] although even small departures can have a large impact when determining age eligibility (e.g. to purchase alcohol or tobacco) is important.

However, the accuracy of age estimates says little about what particular cues are used to make such estimates. Undoubtedly, the face contains multiple sources of information that may guide estimates (*cf.* George & Hole, 2000). The earliest systematic investigations suggested that age estimates were highly sensitive to regularities in craniofacial growth,

[3]The deviation scores reported represent averages which may mask the actual degree of estimation error. For example, large deviations above and below the actual age of an individual would serve to 'cancel out' error and lead to lower estimates. One method of dealing with this issue would be to calculate a score based on the absolute value of deviations, which would only enter the distance and not the direction from the actual value into the calculation. To my knowledge, only Dehon and Bredart (2001) have taken this approach. They reported an absolute deviation score of approximately 7 years from the actual age of photographs presented for age estimation (they also provide information on the proportion of over- and under-estimates). Future studies may benefit by reporting both an absolute and a directional deviation score.

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captured in a mathematical transformation termed *cardioidal strain* (e.g. Mark, Pittenger, Hines, Carello, Shaw, & Todd, 1980; Mark, Todd, & Shaw, 1981; Pittenger & Shaw, 1975a,b; Pittenger, Shaw, & Mark, 1979; see also Bruce, Burton, Doyle, & Dench, 1989). Cardioidal strain is best described as a geometric transformation of the face. Low levels of strain are characterized by a rounded, protruding skull casing, with a small chin and a nose situated at a lower position in the face and sloping downward, all features characteristic of early development. As strain (and perceived age) increases, the skull casing is less pronounced and slopes further backward. The chin becomes more prominent and 'juts out' to a greater degree and the nose is placed higher in the face (see Pittenger & Shaw, 1975a, for specific examples of drawings based on cardioidal strain).

Results of a number studies showed that decreasing or increasing values of strain predictably decreased or increased age estimates made for line drawings of the outlines of faces. That is, even under impoverished conditions in which participants simply had the profile outline of a face to view, age estimates were remarkably sensitive to the level of cardioidal strain. Further work showed that children's age judgements for faces were likewise sensitive to strain (Montepare & McArthur, 1986) and that strain transformations of other types of objects such as ducks, dogs and monkeys (and even Volkswagen Beetles) led to patterns of age judgements similar to that evident for outlines of human heads (Pittenger et al., 1979; but see Mark, Shapiro, & Shaw, 1986, for an exception). Todd and Mark (1981) also demonstrated that cardioidal strain predicted the majority of variability in facial development evident in longitudinal studies of growth. For example, using X-rays of the skull of the same individual taken at several ages, a cardioidal strain transformation applied to growth at 4 years of age could predict the majority of the variability in facial growth at age 19.

The success of cardioidal strain transformations in capturing actual growth and perceptions of growth, however, does not provide a comprehensive account of age-estimation performance. For example, craniofacial growth generally ceases around the age of 20. Thus, we must account for the accuracy of age estimates made for individuals over the age of 20 (e.g. Burt & Perrett, 1995). In addition, the majority of the work on cardioidal strain used simple line drawings of the profile of the face limiting the potential array of cues that might inform age judgements (but see Bruce et al., 1989; Mark et al., 1980; Mark & Todd, 1983, for work with more realistic stimuli). Several studies have in fact shown that line drawings hinder recognition of faces in comparisons to photographs (e.g. Davies, Ellis, & Shepherd, 1978; Leder, 1999), likely because line drawings reduce configural processing of faces (Leder, 1996). In the interest of ease of exposition, a discussion of those studies that go beyond cardioidal strain (and line drawings) alone will follow a rough, tri-partite division focusing on (a) *local features*, (b) *global features* and (c) *group characteristics*. That is, the discussion of cues to age estimation will focus on manipulations made at the local level (e.g. masking of the eyes alone) *vs.* those features that provide information across the entire face (e.g. skin texture).[4] I will also briefly discuss the influence of group characteristics on age estimation.

Local features

Investigations of the impact of local features on age estimation have generally taken the form of altering or obfuscating an isolated feature of the face and determining its impact on

[4]It must be noted that the *global/local* distinction is not isomorphic to that typically made between configural and feature-based processing of faces.

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age estimation (George & Hole, 1998; Jones & Smith, 1984). Jones and Smith (1984) presented 4-year-old children with sets of faces ranging from infancy to older adulthood (70+ years of age) and had participants engage in a sorting task by progressively identifying the oldest individual in a set until that set of faces was exhausted. Faces were manipulated by masking features such as the eyes (while displaying all other face information) or the nose and cheeks. Results showed that children committed the most sorting errors when the eyes were masked. As noted by Jones and Smith (1984), the eye regions may convey a great deal of age-related information. For example, the region around the eyes is highly disposed to developing wrinkles and with age and the loss of adipose tissue the eyes appear to shrink and have a more sunken appearance (Enlow, 1982). However, aside from the fact that this study only tested children, it might also be the case that masking the eyes disrupted processing of the spatial relationship between the eyes, nose and mouth. That is, what appears as only an influence on a single feature may really have its impact on the relationship and interaction between features.

One way to address this issue would be to manipulate a feature or features while leaving the spatial configuration of features intact. Using an ingenious methodology, George and Hole (1998) have conducted such a study. In particular, they obtained photographs of the same individual at two different ages and substituted features between the photographs. Specifically, the eyes, nose and mouth from a photograph of an individual at one age were placed in the same location as the eyes, nose and mouth from another photograph of that same individual at a different age. That is, along with judging photographs that had not been edited at all, participants judged photographs of an 'older' face with young features and a 'younger' face with older features. Results showed that, relative to a young photograph that had not been edited, transplanting older features into a younger face increased age estimates by approximately 40%. In turn, compared to an older photograph that had not been edited, transplanting younger features into an older face decreased estimates of age by approximately 33%. Thus, participants made use of local sources of information to make age estimates. This is not to say that such manipulations may only have their impact at a local level. As George and Hole (1998) note, changing local features may alter the interpretation of the entire head. For example, the smaller nose present in younger adults may change one's view of its relative location. However, what these data do suggest is that manipulations of local features can influence age estimates.

Global features

The importance of global features for the estimation of age is apparent from manipulations that either systematically vary some type of face-wide information or that implement face-wide transformations. Skin texture seems one obvious candidate for a global feature, a possibility recognized by those researchers primarily interested in cardioidal strain. For example, Mark et al. (1980) had participants make age estimates for drawings of faces that crossed cardioidal strain with wrinkling prevalent at different ages. Thus, wrinkling characteristic of a 15-, 30-, 50- or 70-year old was added to craniofacial shapes representative of those same age groups. Both sources of information contributed to age estimates, with wrinkling having a stronger influence than cardioidal strain when the pattern of wrinkling was that of a 50- or 70-year old (see also Montepare & McArthur, 1986).

Other work suggests that manipulations which minimize skin texture information have the effect of 'reversing' the ageing process. George and Hole (1995), for example had participants make estimates for faces ranging in age from 5 to 70. In one condition, faces

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were subjected to a thresholding transformation that created faces which were white with black blobs for features (note that this manipulation still retains information about the relative location and size of features, albeit with less precision). Without skin texture information, age was underestimated by approximately 20 years, a dramatic departure given that estimates for control faces (to which no transformation was applied) were highly accurate. Burt and Perrett (1995) have similarly reported that creating composites (averages) of faces of individuals led to greater levels of error in age estimates compared to a control condition, likely because the process of averaging blurs skin texture information (see also George & Hole, 2000). In addition, George and Hole (1995; 2000; see also Pittenger & Shaw, 1975b) found that participants continued to make reasonably accurate age estimates when only configural information (i.e. the arrangement of features such as the nose, lips, mouth and eyes) was available but not information about head shape. They suggest that even without head shape information, participants could use skin texture as a reasonable cue for age estimates.

However, skin texture alone is insufficient as an explanation of age estimation. For example, the skin also includes colour information related to age. In particular, ageing makes the skin more translucent, with varicosities more evident and the increasingly bony structure of the face that accompanies age may accentuate shadows. Burt and Perrett (1995) report the clearest demonstration that colour information may inform age judgements. They created averages (composites) of faces aged 20–59, and then compared the average for that group to composites of faces aged 50–54. Changes in colour (and shape) between these groups were identified and then the value of that difference was added to faces aged 27, 40 and 52. Results showed that adding such colour information to faces increased age estimates ($M = 5.8$ years), with overestimates greatest when colour information was added to 27-year-old faces ($M = 8.2$ years).

Other evidence also suggests that age estimates may be sensitive to more than skin texture. For example, although George and Hole (1995) reported that underestimates were greatest when information about skin texture was removed by thresholding, the rank ordering of those estimates (i.e. the degree to which older individuals were given higher age estimates) was not entirely askew. Thus, in addition to skin colour (Burt & Perrett, 1995), what other sources of information might inform age judgements? While certainly configural information contributes to age judgements, accuracy does not suffer when configural information is disrupted, as when age estimates are made for inverted faces (George & Hole, 1995). One possibility is that configural information informs judgements, but only when presented in conjunction with head shape information. For example, George and Hole (2000) reported that age estimates were not entirely disrupted when skin information was blurred but shape and configural information was present. Such findings are of course consistent with the work discussed previously examining the relation between cardioidal strain and age estimation (e.g. Pittenger & Shaw, 1975a). In fact, George and Hole (2000) found that age estimation was least accurate when faces were heavily blurred and only configural, but not head shape, information was presented. Thus, there are multiple cues available to estimate age such as skin texture or shape/configural information.[5] Estimation suffers most when both sources of information are distorted or unavailable.

[5]Burt and Perrett (1995) in fact reported that caricatures of both colour and shape information led to greater overestimations (mean = 8.5 years) of age than caricatures of either shape (mean = 4.4 years) or colour (mean = 5.8 years) information alone.

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One more issue with respect to global features warrants further clarification. Given that growth generally does not occur after the age of 20 how might head shape contribute to age estimation? Advancing age leads to a dissipation of the fatty tissue in the face, increasing the 'bony' appearance of the face in older adults (Enlow, 1982). O'Toole, Vetter, Volz, and Salter (1997) have suggested that this might in part contribute to what they term the 'distinctiveness' that accompanies age. Their conclusions are drawn based on work with face caricatures. In particular, O'Toole et al. (1997) created composites based on 100 faces and then transformed faces by amplifying facial features with respect to the average (caricature) or reducing the distance between a face and the average (anti-caricature). Observers' estimates of the age of these faces showed a nearly linear pattern, as estimates of age increased as the degree of caricature increased. O'Toole et al. suggested that, along with accentuating information about wrinkles, the caricatures increased the prominence of the bony structure in the face, leading to higher estimates of age than the same face judged at a lesser degree of caricature. Thus, head shape may be a significant source of information for age estimation even after the cessation of growth (see also Burt & Perrett, 1995).

In sum, a variety of global cues contribute to age estimation. Skin texture and colouration influence estimates along with head shape and configural information, comprising redundant sources of information that can be used to make estimates. Evidence for this comes from several studies indicating that eliminating one source of information (e.g. skin texture, spatial configuration) does not completely impair age estimation (e.g. George & Hole, 1995, 2000). Further, age estimation is most disrupted when multiple sources of information are distorted or unavailable. However, age estimation may also depend on the interaction of the characteristics of the perceiver and the individual to be judged. I examine that issue next.

Group characteristics

A number of group biases have been documented by researchers examining memory for faces. For example, memory for individuals of one's own age (e.g. Anastasi & Rhodes, 2005) or race (see Meissner & Brigham, 2001, for a review) may be superior compared to memory for individuals of a different age or race. Several lines of work have attempted to examine whether group characteristics likewise influence age estimates. Overall, there is some support for the notion that age estimation is more accurate for in-groups than out-groups, but the evidence is inconsistent. Dehon and Bredart (2001), for example had White and Black participants make age estimates for White and Black faces ranging from 20 to 45 years of age. Results showed that White participants' age estimates were reliably more accurate for White faces compared to Black faces. In contrast, Black participants' estimation accuracy did not differ based on the race of the face, a finding that Dehon and Bredart (2001) attributed to the fact that all of the Black participants tested had lived in a predominantly white country (Belgium) for at least 5 years (but see Meissner & Brigham, 2001, for limits to this hypothesis in the memory literature).

More research has examined whether the age of an individual interacts with the age of the individual to-be-judged (e.g. Anastasi & Rhodes, 2006; Burt & Perrett, 1995; George & Hole, 1995; George et al., 2000; Klugman, 1947). Several studies suggest that age estimation is more accurate when one makes estimates of their own age group (Anastasi & Rhodes, 2006; George & Hole, 1995), an effect that may be present as well in children. For example, George et al. (2000; Experiment 3) showed children pairs of faces from nine age categories ranging in age from 1 to 80 and asked participants to identify the oldest face in

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each pair. In general, discrimination was better when both faces in a pair were children than when both were adults (see also Weinberger, 1979). There is also some indication that estimates of age may be biased in the direction of one's own age. Klugman (1947) had participants in their early-to-late 20s and early 30s rate the age of a 25-year-old individual. Results showed a mild tendency for participants in their 30s to provide higher age estimates than those in their 20s (see also Willner & Rowe, 2001). However, other studies have found no evidence of age dependencies in estimation performance (e.g. Burt & Perrett, 1995).

Taken together, data on group biases in age estimation must be regarded as suggestive that in-group age estimation is superior to that of out-group age estimation. This may include more accurate age estimates for individuals of one's own ethnicity or age group (but see Burt & Perrett, 1995). However, given the dearth of data, the full range and impact of group biases on age estimation has yet to be explored.

FUTURE DIRECTIONS

In addition to more fully examining possible group predictors of age estimation, there are a number of other issues that remain to be examined. Foremost among these, the possible range of cues that potentially contribute to age estimates has certainly not been exhausted. Regarding facial cues, very little work has specifically manipulated the style, colour or quantity of hair, leaving some question as to how hair contributes to age estimates (but see Burt & Perrett, 1995). For example, greying hair might lead to overestimates of age for younger individuals whereas a full head of hair lacking any grey colouration might lead to underestimates of age for older individuals. Such a pattern would suggest that hair information contributes to age judgements even when other information (e.g. facial shape, skin texture) is present. Given the large industry devoted to making people appear younger (e.g. botox treatment, hair colouring and restoration), such issues warrant further research.[6]

A variety of contextual cues might also influence age estimates. This could include such factors as style or manner of dress, the age of individuals in a group, the putative occupation of an individual or other indices of a behaviour which may impact real world estimates of age. For example, does wearing formal attire such as a business suit, associated with age groups beyond the teen-aged years, inflate age estimates? As well, suggesting that an individual is employed in an occupation associated with many years of training (e.g. doctor) might likewise inflate age estimates. Regarding peer groups, it might also be the case that estimates of age would be influenced if the age of an individual was judged in the context of a group of comparatively older or younger individuals. The larger issue with regard to such contextual manipulations is the degree to which seemingly extraneous information may contribute to or bias age judgements. It is perhaps a trivial point with regard to our understanding of how the face conveys information about age but is far from

[6]As a reviewer noted, height may be another cue to age worth examining. The age estimation literature has almost exclusively presented faces alone for age estimates but there is a small literature examining children's age estimates as a function of the size of a photo. For example, Looft (1971) had children make discrimination judgements for drawings of individuals, identifying the older individual of a pair. The size of the drawings was manipulated, with children judging individuals presented on 3.5″ or 5.5″ cards. Results showed that children frequently selected the larger drawing as the older individual, even when their answer was incorrect, a trend that disappeared around the age of 9 or 10 (see also Kratochwill & Goldman, 1973; Looft, Rayman, & Rayman, 1972). However, to my knowledge, the potential influence of the height or size of an individual on age estimation has not been examined with adults.

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trivial for an individual attempting to make age estimates (such as a clerk) when presented with such contextual information in addition to information conveyed by the face alone.

There are also a number of applications of age-estimation research to the legal system that would be well served by further investigation. Descriptions of suspects frequently include age estimates and the data reviewed suggest that such estimates are fairly accurate. However, the majority of studies on age estimation are conducted under ideal viewing conditions, with appropriate lighting and without time constraints. A witness may only be permitted a brief glimpse of a suspect under poor lighting conditions with portions of the face obscured. Although age estimation is not entirely impaired when some portions of the face are not visible (e.g. George & Hole, 1995, 2000), it is not clear how age estimation performance fares under poor viewing conditions or under stress. There is some work to suggest that rough classifications of a face as old or young following a brief presentation (200 ms) are reasonably accurate (e.g. Bruyer et al., 2007; Bruyer, Lafalize, & Distefano, 1991) but evidence regarding the accuracy of more precise estimates following brief presentations is currently lacking. Thus, our understanding of age estimation would benefit from investigations of accuracy under a variety of impoverished viewing conditions.

Finally, age estimation accuracy may be amenable to training. For example, as previously noted, there are several reports suggesting that clerks often overestimate the age of minors attempting to purchase alcohol (Jason et al., 2003; Merrill et al., 2000). Training programmes that could enhance age-estimation accuracy would therefore be of great benefit to individuals charged with limiting access to products or services on the basis of age. To my knowledge, only one age estimation training programme has been reported. Specifically, Sörqvist and Eriksson (2007) had participants practice making age estimates for groups of young (15–24 years of age), middle-aged (34–46 years of age) and older (56–65 years of age) adults. Participants in a training group made age estimates and were given feedback in the form of the actual age of the individual. A control group practised making age estimates but was not provided feedback. Results showed that the provision of feedback improved performance relative to participants who were not given feedback. However, while very promising, improvements were restricted to estimates of the ages of older adults, limiting the utility of this training programme for age estimation of young adults, for whom age-restriction policies are most relevant. Such findings set an agenda for future research to develop training programmes which can successfully improve the accuracy of estimates across a range of ages.

CONCLUSIONS AND POLICY IMPLICATIONS

Overall, the literature on age estimation suggests that we are remarkably accurate at estimating the age of unfamiliar faces over a broad range of ages, but biases also exist (e.g. Burt & Perrett, 1995; George & Hole, 1995, 1998, 2000; Henss, 1991). In addition, age estimation can be quite robust with respect to transformations that selectively remove facial information (e.g. George & Hole, 1995, 2000). The evidence points to multiple cues that contribute to age estimation, including those related to craniofacial shape (i.e. cardioidal strain), skin (e.g. texture and colour), the configuration of spatial features, and even local features of the face such as the eyes. There is also some indication that age estimation may vary based on group characteristics, with in-group estimation more accurate than out-group estimation.

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How might the research reviewed inform policy decisions regarding what age groups should be asked for age identification? While caution should always be exercised when attempting to apply laboratory research towards policy recommendations, the research on age estimation does have a contribution to make to such discussions. The general conclusion that can be drawn is that while age estimation is quite accurate, it is not sufficiently accurate that individuals can reliably make fine-grained distinctions. In particular, the available laboratory evidence suggests that errors on the order of 1 to 4 years are common. When coupled with evidence from field studies indicating that clerks may often make mistakes in age estimation (e.g. Jason et al., 2003; Merrill et al., 2000; Willner & Rowe, 2001) the bulk of the evidence is supportive of mandates that clerks ask for identification for a range of ages well above the legal minimum required for access to a product or service. Given that simply asking for age identification is a powerful deterrent to minors' access to alcohol and tobacco (e.g. Clark, Natanblut, Schmitt, Wolters, & Iachan, 2000) it would seem prudent that such access is not reliant on distributors making subtle age distinctions. Age estimation may be amenable to training (Sörqvist & Eriksson, 2007) but the safest policy is likely that which only requires gross distinctions of age.

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