Original Article

How portraits turned their eyes upon us: Visual preferences and demographic change in cultural evolution

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A B S T R A C T

It has often been suggested that innate features of the human mind could make some cultural forms more successful than others. This paper presents a case study consistent with this "cognitive attraction" hypothesis. Numerous studies show that direct eye-gaze catches the attention of adults and newborns. Adults find it more attractive. We explore one possible cultural consequence of this cognitive appeal. Among XVIth century European portraits, direct-gaze paintings are more likely to be featured in today's art books. In Renaissance Europe, the proportion of paintings that stare at the viewer grows gradually, strongly, and remains prevalent for centuries. A demographic analysis of this shift shows that it was due to the arrival of new generations of painters. Those artists show a preference for direct-gaze portraits as soon as they start painting, suggesting that they acquired the new style in the years of their apprenticeship. The preferences of those painters and of contemporary art critics seem consistent with the innate attentional bias that favours direct-gaze faces. The structure of the "Renaissance gaze shift" bears evidence for the importance of demographic turn-over in cultural change.

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1. Introduction

You probably have in your wallet, or on your hard disk, a representation of a human face that seems to be looking out of the picture into your eyes. This visual illusion is so common we hardly notice it. Yet its effects on our mind are far from trivial (Wollaston, 1824). As compared to a slightly averted gaze, direct eye-gaze in pictures facilitates identification and gender assignment (Macrae, Hood, Milne, Rowe, & Mason, 2002; Vuilleumier, George, Lister, Armony, & Driver, 2005). Direct eye-gaze is attention-grabbing as well. Staring faces make more potent distractors than averted-gaze faces (Conty, Gimmig, Belletier, George, & Huguet, 2010; Senju & Hasegawa, 2005). Direct-gaze faces are more arousing, as evidenced by physiological measures such as galvanic skin response (Nichols & Champness, 1971). Direct-gaze pictures of faces (even neutral faces) are rated by subjects as more "likable" or "attractive" (Conway, Jones, DeBruine, & Little, 2008; Ewing, Rhodes, & Pellicano, 2010) — but see Hietanen, Leppänen, Peltola, Linna-Aho, and Ruuhiala, (2008). Some of these effects of direct eye-gaze are probably due to innate features of our visual system. Children as young as three days old preferentially look at direct-gaze pictures of still faces (Farroni, Csibra, Simion, & Johnson, 2002). Direct eye-gaze facilitates identification in 4 months-old as it does in adults (Farroni, Massaccesi, Menon, & Johnson, 2007).

Several authors have suggested that open eyes facing the viewer were ubiquitous in various artistic traditions, given their psychological impact (Cross, 2003; Eibl-Eibesfeldt, 1988). Yet for all their cognitive appeal, direct-gaze depictions of the human face are not a universal standard, far from it. Identity documents are overwhelmingly direct-gazing (indeed that is often a legal requirement). So were Greek and Egyptian funerary portraits. Yet, in many other traditions (Indian and Japanese portraits, for instance) direct eye-gaze is hardly ever present. Most portrait traditions are constrained by rigorous (and possibly arbitrary) norms concerning the sitter's pose. In many cases, these artistic standards can mesh with local norms governing gaze behaviour. Many cultures implicitly forbid staring in some contexts. Those norms may have an incidence on portraits, especially when they are painted for ritual purposes. Korean official portraits, for instance, came from a court society where etiquette frowned upon gazing. Asked to check that the King's portrait was faithful, some officials remarked that they could not know: they had often been in the King's presence, but never looked at his face (Sŏng-mi, 2008 p. 120). Thus, there is no denying that gaze direction in portrait traditions varies a lot. This paper contends, however, that in traditions where gaze direction is left free to vary, so that we find both averted and direct-gaze portraits, the latter style should enjoy more success and, over time, become the default option.

A growing body of work shows that a "cognitive attraction" drives many cases of cultural evolution (Sperber & Hirschfeld, 2004). Widespread cognitive biases appear to constrain the evolution of cultural forms, from folk tales (Norenzayan, Atran, Faulkner, &

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Schaller, 2006) and urban legends (Heath, Bell, & Sternberg, 2001) to table manners (Nichols, 2002) and religious beliefs (Boyer & Ramble, 2001). Concerning portraits, Costa and Corazza (2006) show that painters exaggerate "neotenic" features in their portraits: traits like big eyes or round faces, which make faces seem more attractive to viewers across many cultures and from the youngest age.

If cognitive attraction played a role in the evolution of paintings, it should contribute more to the fame of direct-gaze portraits. It should favour, over time, a gradual replacement of averted-gaze portraits with direct-gaze portraits. We should also be able to identify the drivers of this evolution, and identify the kind of mechanism that explains the change (e.g., individual learning or demographic change). Each one of these questions asks how cultural evolution and cognitive attraction, two phenomena that are often studied separately, may influence one another. To answer these questions, we used a quantitative analysis of Renaissance portraits (Mcmanus & Humphrey, 1973; Tyler, 1998). Three studies looked at the effect of cognitive attraction on the evolution of direct eye-gaze from different angles. Study 1 shows that direct-gaze portraits are cognitively attractive with today's critics: they are more likely to be featured in art books. Study 2 shows a sustained shift in the Renaissance portrait traditions, favouring direct-gaze portraits. Study 3 shows that the shift was due to the arrival of new generations of painters, not to a change in the way sitters posed, to a change in the style of individual painters, or to a preservation bias.

2. Study 1: Did direct-gaze portraits become more famous than others?

European portraiture was chosen because (unlike most portrait traditions) it produced both averted-gaze and direct-gaze portraits. (A similar tradition, Korean portraiture, was studied as well with similar results. See Electronic Supplementary Materials, 1, available on the journal's Web site at www.ehbonline.org, and our conclusion). Our investigation focuses on the XVIth century (a period that is as well studied as the XVth century and was much more productive). European portraiture is a fairly recent tradition by global standards. Single-piece ("autonomous") portraits were rare before the XVth century. Yet those earliest autonomous portraits also show a near absence of direct eye-gaze. It seems that we are dealing with a tradition where direct-gaze portraits were, at first, unknown or excluded by the artistic standards of the time.

2.1. Material selection and coding

The portraits included in this study were single original paintings where the painter tried to depict one other human individual's real appearance. This definition and the exclusion criteria it implies are detailed in the Electronic Supplementary Materials, 2 (available on the journal's Web site at www.ehbonline.org). Two big Internet databases were searched for European portraits: the JOCONDE database, which gathers paintings from most French public museums, and the WEB GALLERY OF ART database, which gathers paintings from the inventories of the most important museums in the world. 671 paintings were found.

Information was collected on the sitter's sex and notoriety. Sitters were classified between Identified sitters, who were either named or identified in some other way (e.g. "The artist's mother"), and Unidentified sitters. Identified sitters were classified into Famous and non-Famous. Sitters possessing an entry in one of five versions of Wikipedia (Italian, German, French, Dutch, Spanish, English) were Famous. Sitters who had an entry devoted to their portrait, not to their person, were not coded as Famous. (Only one sitter, Mona Lisa, could be said to have gotten into Wikipedia *only* because of her portrait). For

each portrait, the national "school" of the artist ("Italy", "France", "Germany", "Netherlands", "Spain") was recorded.

All portraits were double-coded for gaze direction. As a first step, the author and a second coder coded all the paintings independently (Cohen's Kappa = 0.896, S.E. = 0.018). Most disagreements were solved by discussion. Persistent disagreement caused the discarding of 15 paintings (leaving 656 paintings).

Inclusion in an illustrated art book was used as an indication of a portrait's current fame. Such books typically present themselves as providing a selection of the best and most famous paintings from a given period. Most authors provide a reproduction of at least some of the most famous paintings of a given age (for instance, the *Mona Lisa*, Raphael's *Balthazar Castiglione* and Bellini's *Leonardo Loredano* were all reproduced in the majority of books). Are direct-gaze portraits in our two corpora more likely to be reproduced in art books because of this?

2.2. Selection of art books

Since mainstream, commercial books were needed, Web sites amazon.fr and amazon.com were searched exhaustively for books featuring a selection of portraits from our two traditions (see Electronic Supplementary Materials, 3, available on the journal's Web site at www.ehbonline.org, for the full lists of inclusion criteria and books). 11 books were found that fit our criteria. Many can be described as "coffee-table books", i.e. they were sold for their aesthetic value at least as much as for their scientific value. The books came from five different countries. No book provided more than 25% of the reproductions, and most books provided more than 8%. As expected, there was a good deal of overlap between the books: 48% of reproduced paintings were reproduced in more than one book.

2.3. Analysis and results

A logistic regression was run using a portrait's presence in one of the art books as the dependent variable. Independent variables were the painting's date (measured in decades), the sitter's status, the sitter's gaze, the painter's school and the sitter's sex.

Table 1 displays the results. The art books selection of portraits is oriented in non-random ways. The prototype of the famous portrait is, so to speak, a Mona Lisa: a well-identified Italian woman (typically a daughter of a powerful family or the wife of some important bourgeois), painted in the first decades of the XVIth century. Like

Table 1
Logistic regression modelling the inclusion in art books of 656 European Renaissance paintings.

	B	S.E.	Wald	d.f.	Sig.	Exp(B)
Gaze (direct)	.650	.239	7.387	1	.007	1.916
Date (in decades)	−.239	.051	21.774	1	.000	0.788
Notoriety			33.368	2	.000	
Identified	1.290	.247	27.304	1	.000	3.631
Famous	1.687	.389	18.788	1	.000	5.403
Area (reference: Italy)			7.321	5	.008	
Germany	−.728	.304	5.720	1	.017	.483
France	−1.663	.511	10.579	1	.001	.190
Netherlands	−.673	.340	3.932	1	.047	.510
Spain	−.202	.698	.083	1	.773	.817
England	−.653	1.202	.295	1	.587	.520
Sex (woman = 1)	0.738	.237	9.718	1	.002	2.092
Constant	−0.744	.376	.921	1	.337	0.697

	χ^2	d.f.	sig.		
Omnibus model test	78.015	10	.000	Nagelkerke's R^2	18,2%
Hosmer–Lemeshow test not significant (p=0.574)				percentage correct	82,50%

the *Mona Lisa*, famous paintings gaze at the viewer: direct-gaze portraits are significantly over-represented by our sample of books. The effect is much clearer when the above factors are controlled for, since art books favour portraits of famous sitters (who tend to avert their gaze) and portraits that were painted before the start of the shift towards direct eye-gaze that study 2 describes.

Post hoc analyses showed that the advantage associated with direct eye-gaze is specific to anonymous paintings. Repeating the above analysis with portraits of famous and otherwise identified sitters alone (N = 308, overall model fit, p<.001, Nagelkerke's pseudo-R^2 = 13.4%), one finds only a weak and non-significant effect of gaze direction on a portrait's fame (Exp (B) = 1.362, p>.3). The same analysis with anonymous sitters only (N = 348, overall model fit, p<.001, Nagelkerke's pseudo-R^2 = 22.4%) finds a strong effect of gaze (Exp (B) = 3.912, p<.01). Arguably, paintings whose sitters are famous enough to have left a name in history do not need to attract the viewer's attention quite as much as others.

2.4. Discussion

Inclusion in an art book reflects a multiplicity of factors, some of which have to do with conscious choices (of buyers, of historians, of curators, etc.), some others being accidents. Together, those factors favour direct-gaze paintings over others, *ceteris paribus*. There are reasons to think that art critics' choices are not completely idiosyncratic, and reflect a broader consensus. In a quantitative study considering the posterity of late XIVth and XVth century Flemish and Italian painters, Ginsburgh, Mairesse, and Weyers (2008) find that critics' appreciations exhibit a remarkable consistency through time (see also Gilbert, 1980, pp. 95, 175, 192).The painters and works covered at length in Vasari's mid-XVIth century guide (Vasari, 1998) are still the most famous today (the Mona Lisa, the Sistine Chapel ceiling, Raphael's work, etc.). Important paintings were on view in the most public parts of their owner's dwelling. Painters and amateurs could often visit them. Portraits of famous people were displayed in public on feast days. Masterpieces were copied by hand in several exemplars, and circulated as etchings, engravings and printings.

Thus, we have reasons to believe that direct-gaze portraits were appealing during the Renaissance as well as today. If so, this should have led to an increase in the proportion of portraits that seem to gaze at the viewer. Study 2 tests that prediction.

3. Study 2: Is the evolution of Renaissance portraits consistent with cognitive attraction?

3.1. Analysis and results

The same sample used in Study 1 was used for this study. A logistic regression was run, using the direction of gaze (direct or averted) as the dependent variable. The predicting variables were the painting's date (measured in decades), the sitter's status, the painter's national school and the sitter's sex. Results are displayed in Table 2. The model we obtained predicts the presence or absence of direct eye-gaze in a portrait with an acceptable fit.

A strong (and significant) effect of the *date* variable was found. With each passing decade, direct-gaze portraits were 20% more likely (see Fig. 1). Other analyses, performed on subgroups of the European sample, showed the effect to be well distributed. The effect is obtained when considering only women, only men, only anonymous sitters, only identified sitters, paintings from the JOCONDE database only or paintings from the WEB GALLERY OF ART only (for all these analyses, the effect of time is significant at p<.05 at least; Exp (B) from 1.150 to 1.421. Overall model fit: Omnibus test's p<.05).

In Europe, famous sitters (as opposed to identified ones) were less likely to look at the viewer. This can be seen as confirming the

Table 2
Logistic regression modelling the presence of direct eye-gaze in a portrait, for 656 European Renaissance paintings.

	B	S.E.	Wald	d.f.	Sig.	Exp(B)
Date (in decades)	0.199	.038	26.736	1	.000	1.220
Notoriety			7.239	2	.027	1.621
Identified	.483	.331	2.128	1	.145	1.632
Famous	.490	.189	6.673	1	.010	1.220
Area (reference: Italy)			23.023	5	.000	
Germany	−1.024	.232	19.420	1	.000	.359
France	−0.272	.299	0.823	1	.364	.762
Netherlands	−0.378	.244	2.415	1	.120	.685
Spain	1.635	1.047	2.441	1	.118	5.130
England	−0.475	.970	0.240	1	.624	.622
Sex	−0.105	0.196	.285	1	.593	.901
Constant	−0.349	.365	.912	1	.340	.706

	χ^2	d.f.	sig.		
Omnibus model test	12.713	4	.013	Nagelkerke's R^2	25,4%
Hosmer–Lemeshow test not significant (p=0.982)				percentage correct	83,80%

notion (widespread in art history lore, see e.g. Beyer, 2003) that would-be dignified people tended to avert their eyes (though it should be stressed that this is a tendency, not a rule). The Italian school seems to favour the direct-gaze pose more than most European schools (the Germans in particular). Somewhat surprisingly, the sitter's sex did not seem to influence gaze direction.

3.2. Discussion

A follow-up search was carried on to check whether the shift was a permanent change, as opposed to a cyclic fluctuation. A random sample was drawn from the JOCONDE database, using the last digit of each paintings' inventory number. For every period of 99 years from 1440 to 1939, 25 paintings were included, for a total of 125 portraits. The five centuries period started in 1440 because no adequately dated portraits were found before that date (the one exception being a XIVth century portrait that does not look at the viewer). The analysis shows that the rate of direct-gaze portraits never went back to its pre-1540 level: averted-gaze portraits appear to have been a minority ever since (Fig. 2). European portraits, however, did not go the whole way: they start oscillating around a proportion of 75% direct-gaze portraits from the XVIIth century on. Like many other forms of psychological attraction (the attraction of alcohol in drinks or salt in food, for instance), the visual appeal of direct eye-gaze may be dose- or frequency-dependent: there can be too much of a good thing. Cognitive attraction could favour a biased mix where direct-gaze portraits are a majority.

One may wonder why this shift took place at that time and not earlier. One possible explanation is that XVth century portraits favoured two poses: profile, and three-quarters. The latter would later become the dominant pose (accounting for more than 90% of our sample). Both configurations naturally discourage direct-gaze portraits: combining the three-quarters pose with a direct eye-gaze was not a trivial innovation. It might not have been invented more than once or twice. Van Eyck (c. 1380-1441) was one of the first to use the combination, probably imitated by Antonello da Messina (c. 1430-1479) who applied it systematically (Campbell, Falomir, Fletcher, & Syson, 2008, pp. 100–101).This innovation and its diffusion made the shift possible.
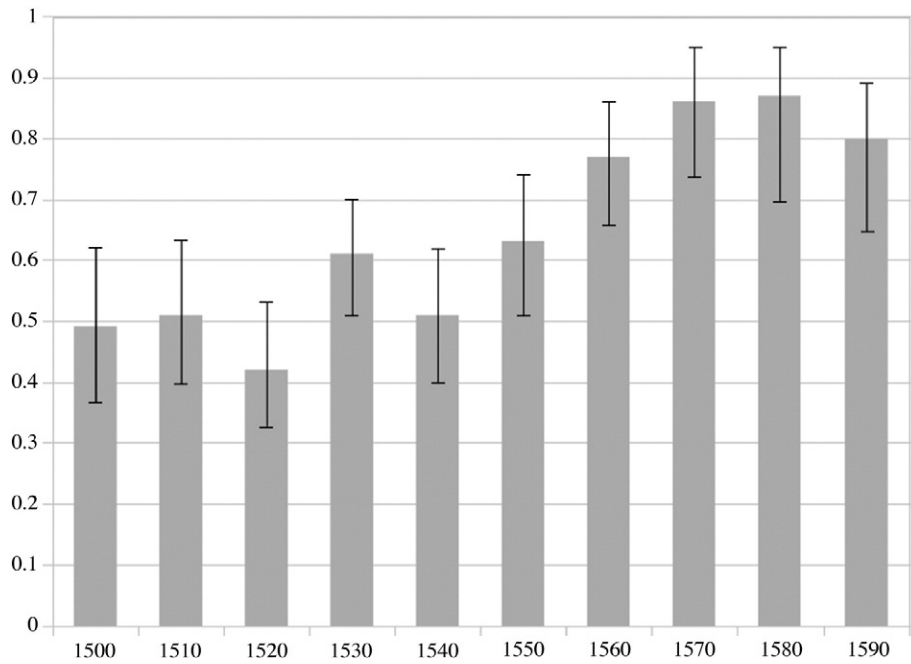
Fig. 1. Proportion of direct-gaze paintings in European Renaissance portraits (1500–1599), decade by decade, shown with 95% confidence intervals (Wald test).

3.3. The "Apprentice Hypothesis"

The observed shift may be explained in at least three ways.

First, the shift may have nothing to do with painters. They may have been "photographing" a social change that had nothing to do with their style. The European Renaissance is commonly associated with important mind-set changes – protestant plainness, bourgeois equality, etc. – that might have affected the body language of Renaissance women and men. More trivially, the shift may reflect a bias in the preservation of paintings, which was certainly quite poor (van der Woude, 1991). If losses and destructions were (somehow) sensitive to gaze direction, this could create the appearance of a shift.

In all these hypotheses, painters do not drive the change themselves. External circumstances do. Painters might as well be cameras: this is the "Photo Booth Hypothesis". If it is true, we should observe more direct-gaze portraits in later paintings, *ceteris paribus*. In

any decade, younger painters should not paint more direct-gaze portraits than others, but within a given generation, painters should paint more direct-gaze portraits as they age.

Second, the shift may be due to a change in painters' individual styles. This change may have two roots. First, painters may learn from their successes and failures that their clients share a fondness for direct eye-gaze. Second, painters may want to imitate their colleagues, who paint more direct-gaze portraits, thereby feeding a conformist cycle. In both cases, individual painters increase the proportion of direct eye-gaze in their portraits as they grow more experienced. This experience may later be communicated to the next generation. This will be called the "Learning Hypothesis". If it is accurate, we should observe that, *ceteris paribus*, older painters should paint more direct-gaze portraits.

Thirdly, the shift may be due, not to a change *in* painters, but only to a change *of* painters. In this hypothesis, painters learn to paint a
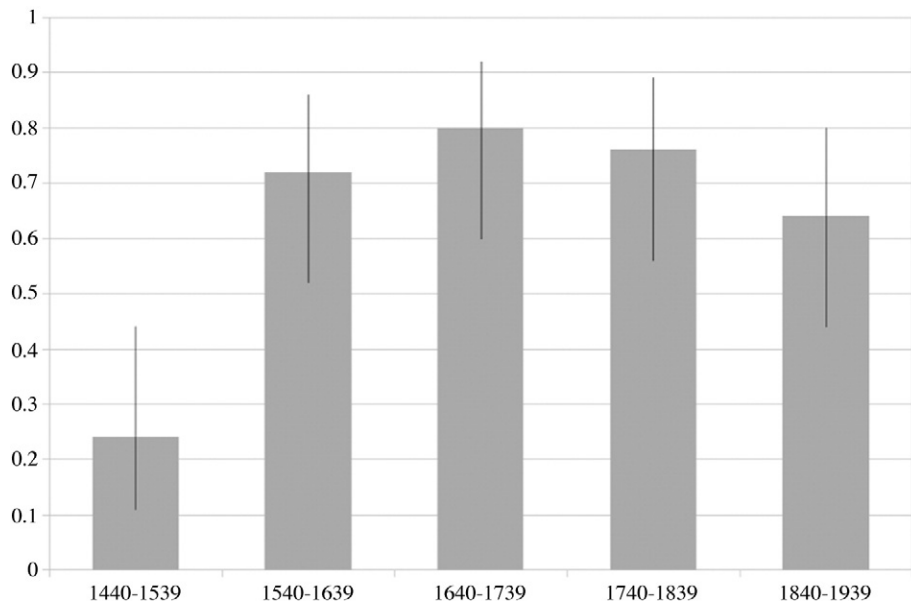

Fig. 2. Proportion of direct-gaze paintings in a random sample of 125 European portraits (1440–1939), shown with 95% confidence intervals (Wald test).

certain proportion of direct-gaze portraits during apprenticeship, by copying the most famous paintings, which happen to be (mostly) direct-gaze portraits. As a result, new painters would paint more direct-gaze portraits than older contemporaries and earlier painters. In this view, the shift is triggered by a change of painters: the gradual replacement of "averted eye-gaze" generations by "direct eye-gaze" generations. Yet this change of painters is not caused by a change in painters: painters should not necessarily increase the rate of direct eye-gaze in their portraits with experience. That is the "Apprentice Hypothesis". If it is accurate, older painters inside a given generation should not paint more (or less) direct-gaze paintings than others. At a given time, younger painters should paint more direct-gaze portraits, since they belong to a later generation.

4. Study 3: Was the shift due to a change in painters or to a change of painters?

There is a way one can rule out the "Photo Booth Hypothesis" and the "Learning Hypothesis". The respective influences of painter-independent changes, changes in painters and changes of painters can be teased out by measuring the effect of three parameters on portrait gaze: the painter's date of birth (hereafter called the *generation* variable), his *age* at the time he made the portrait, and the *date* of the portrait's execution.

4.1. Study 3a: the respective effects of portrait date, painter's age, and painter's generation

The corpus used for Studies 1 and 2 was used, after removing every portrait whose painter could not be dated with a precision of at least 10 years. 95 portraits were thus excluded, leaving 561 paintings. Two regression analyses were run, taking gaze direction as dependent variable. The first analysis used *age* and *generation* as independent variables. The second analysis used *age* and *date*. Table 3 shows the results of the two regressions.

Unsurprisingly, *generation* and *date* (controlling for *age*) have exactly the same effect in both analyses. This is because measuring *birth* or *date* while controlling for age captures exactly the same two things, namely 1) painter-independent changes and 2) changes of painters. In fact, both models (*date + age* or *birth + age*) are given exactly the same information: the painter's age and his

position in time. As a result, the two models share the same overall parameters.

The first model shows that *age*, controlling for *birth*, has no important or significant effect: paintings executed by painters from the same generation, but at a later time, increase their odds of showing direct eye-gaze by only 2 % with each passing decade. Most of the shift is captured by the *generation* variable — that is to say, by a change of painters, not by a change in painters.

This is what the Apprentice Hypothesis predicts: in this analysis, the *generation* variable captures differences between successive generations. One aspect of demographic change that should also have an effect on the prevalence of direct eye-gaze is not captured by the comparison of *age* and *generation*: the juxtaposition of different generations at a given time (as opposed to the synchronic effect of passing generations). This aspect is expressed in this model by the significant constant term; it is analysed by the second model.

In the second model, *age* has a negative effect when controlling for *date*, implying that at any given time, painters of the earliest generations are the least likely to paint direct-gaze portraits. Painters belonging to later generations are thus more likely to paint direct-gaze portraits. This supports the Apprentice Hypothesis and contradicts the other two hypotheses. As expected, the analysis also finds a positive effect of *date*, which is the exact equivalent to the positive effect of *generation* in the first model: later painters (in other words, late-generation painters, whatever their age), are more likely to produce direct-gaze portraits.

4.2. Study 3b: The first decade of 28 painters

The above analyses suggest that young painters start their career with a style that markedly differs from that of their contemporaries, as far as gaze direction is concerned. Importantly, this difference does not depend on later learning: it is present from the very start of a painter's career. A painter-by-painter analysis, focused not on portraits but on portrait-makers, was carried out to explore this consequence.

In our data, all the works of painters born after 1480 and producing at least three portraits, at least two of which were produced in the first decade of their career, were selected (no painter born before 1480 started his career in the 1500s or later). The proportion of direct-gaze portraits was measured for each of the 28 painters. This rate was compared to the average proportion of direct-gaze portraits in paintings produced, during that decade, by other painters of all ages. To keep productivity equal, painters who produced less than three portraits were excluded here as well (the effects of this exclusion did not go in the direction favoured by our hypothesis). The comparison of the two proportions yielded a ratio (the departure ratio) for each painter. It measured by how much the work of his first decade departed from the style of his contemporaries.

Having checked that this departure ratio was normally distributed (Kolmogorov–Smirnov test, p>.950), a two-tailed one-sample T-test was run to test whether it differed significantly from 1. Young painters had a departure ratio of 1.24 on average (S.D. 0.56), significantly higher than 1 (2-tailed, t = 2.260, p = 0.032) (Fig. 2). Those first paintings were mostly painted when authors were in their twenties or thirties (2.6 decades on average). Interestingly, half of the 28 painters began their career in the first three decades of the XVIth century, that is to say, decades before the shift started in most countries. These young painters anticipated it by several decades. They allow us to observe the shift, so to speak, before it happens.

4.3. Discussion

The three predictions of the Apprentice hypothesis are validated. The shift appears to be due above all to a change of painters, as shown by the negative effect of *age* controlling for *date*. This suggests that neither painter-independent changes nor changes in painters

Table 3
Logistic regression modelling the presence of direct eye-gaze in a portrait, in 561 European Renaissance portraits.

	B	S.E.	Wald	d.f.		Sig.	Exp(B)
Analysis 1:							
Painters' date of birth (in decades)	0.246	.041	36.858	1		.000	1.279
Painter's age when painting (in decades)	0.021	.070	.087	1		.769	1.021
Constant	−1.718	.505	11.580	1		.001	0.179
Analysis 2:							
Painting's date (in decades)	0.246	.041	36.858	1		.000	1.279
Painter's age when painting (in decades)	−0.226	.071	10.003	1		.002	0.798
Constant	0.027	.256	.011	1		.917	1.027
For both analyses:							
	χ^2	d.f.	sig.				
Omnibus model test	47.109	4	0.000	Nagelkerke's R^2		10,70%	
Hosmer–Leshow test not significant: (p = 0.119)				percentage correct		66,4	

Analysis 1: Gaze as modelled by painter's generation and painter's age.
Analysis 2: Gaze as modelled by painting's date and painter's age.

drove the shift. No support was found for the "Photo Booth" hypothesis: the shift cannot be explained by the way Renaissance portraits were conserved, collected, selected, or faked. The change came from the painters' style rather than from people's behaviour. Our results also support the hypothesis of a demographic change driving the shift, with little or no contribution from individual experience. The shift was fed by the arrival of new generations of painters who adopted a different style while they were apprentices, or just after (Figs. 3 and 4).

Study 3b may underestimate the extent to which young painters departed from the style they encountered when they were apprentices. We know from contemporary witnesses such as Vasari (1998) or Van Mander (Mander, 2001a,b) that most painters became apprentices in their teenage years, and started painting much before they could sign their own work (Gilbert, 1980, pp. 31, 163, Hauser, 1951: 46 sq.). Also, they would have painted works lost to us before their first portrait appears in our records. Thus, young painters probably formed their style before the time when we can first measure it, which makes their departure from the standard of their time even more striking.

Young painters reproduced the style of the previous generations with a bias consistent with cognitive attraction. This fact is compatible with a variety of scenarios. In the first scenario, young painters transformed their elders' style while copying it. This is a frequent cause of cultural change: new generations modify the input they receive, to fit cognitive constraints. This mechanism is often said to drive linguistic change (Lightfoot, 2006).

There is another possibility, however. Perhaps young painters were exposed to a biased sample of the work of earlier generations, a sample in which direct-gaze portraits were overrepresented. Study 1 showed such a bias in today's famous Renaissance portraits, and we gave reasons to think that current fame correlates with past fame. We also know from contemporary witnesses that young Renaissance painters learnt by copying (Gilbert, 1980 pp. 156, 163; Mander, 2001a,b; Vasari, 1998). Testimonies also mention that they copied mostly the great

masters of their day (Mander, 2001a pp. 163, Mander, 2001b pp. 98, 174, 222; Vasari, 1998, pp. 345, 377, 418). Apprentices may simply have copied famous paintings from earlier generations. A bias in this sample of illustrious portraits triggered a shift toward direct eye-gaze.

5. Conclusion

The view that a general preference for direct eye-gaze influenced XVIth century portraiture was tested in three different ways. In Study 1, we saw that direct-gaze portraits were more likely to be selected by books gathering the "best" paintings of their tradition. Study 2 showed that Renaissance portraiture gradually evolved towards a strong predominance of direct eye-gaze. Study 3 showed that this shift was due to the gradual replacement of early painters by new generations of painters, who started their career by painting more direct-gaze portraits than their contemporaries, before the shift became tangible.

Young painters of the High Renaissance, although they grew up in a visual culture that differed starkly from ours, seemed to share an aesthetic preference also found in today's art critics and in the subjects of Western psychological experiments. It is tempting to link this preference with our innate propensity to look at direct-gaze faces. This conclusion would be premature, however. Before embracing it, we would like to make sure that the preference of sixteenth-century painters for direct eye-gaze was not itself the product of a historical accident, and that studies 1 and 2 can be replicated in a suitable variety of independent portrait traditions. Two things seem to warrant a careful optimism on both grounds.

The first element is the great variety of painters, from different national and stylistic backgrounds, who followed the trend. True, these painters were connected with each other by a series of pan-European visual revolutions, but none of these appear sufficient to explain the rise and sustained dominance of direct-gaze portraits. The European diffusion of Mannerism outside Italy roughly coincides with the peak of the XVIth century shift (c. 1560–1580), and there is
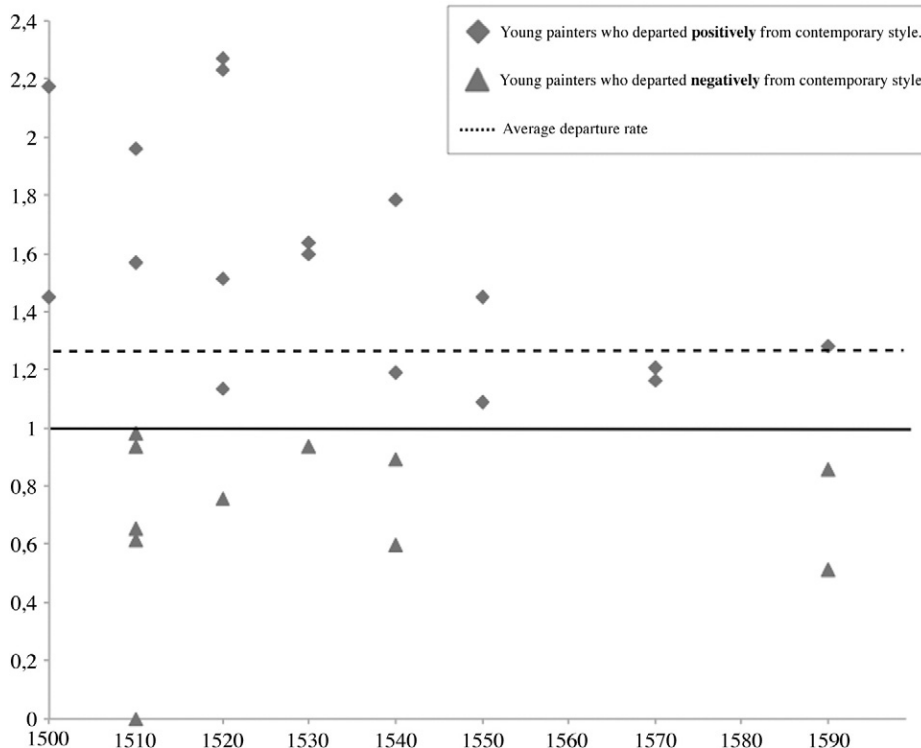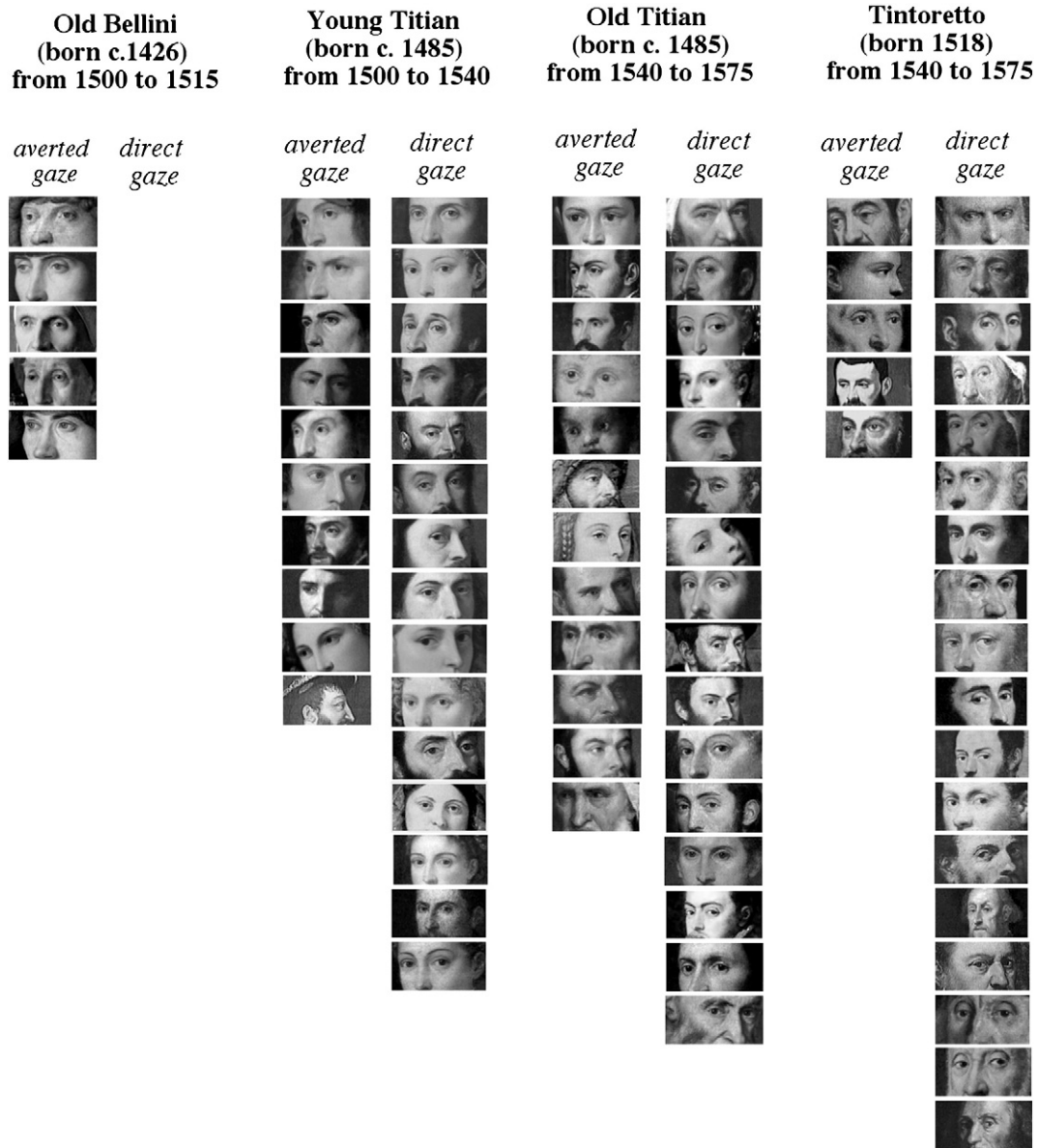

Fig. 3. Proportion of direct-gaze portraits in the first decade of the recorded production of 28 painters, as compared to their contemporaries, plotted against the decade of each painter's first portraits (1500–1599). Five overlapping data points have been shifted downwards slightly for better visibility.

Fig. 4. Three generations of portrait-makers in Venice. This figure, showing, from 1500 to 1575, all paintings by Venice painters Bellini, Titian and Tintoretto in our data, illustrates the Apprentice hypothesis. Titian, whose career spanned three quarters of a century, painted more direct-gaze paintings than his master Bellini, but fewer than his later contemporary Tintoretto. The proportion of direct-gaze portraits in Titian's work does not grow from one half of his career to the other. The paintings come from the following collections: Staatliche Museen (Berlin), Musée des Beaux-Arts (Besançon), Szépmûvészeti Múzeum (Budapest), Gemäldegalerie (Dresden), Galleria degli Uffizi & Galleria Palatina (Palazzo Pitti) (Florence), Museum voor Schone Kunsten (Ghent), Nelson-Atkins Museum of Art (Kansas City), Garrowby Hall (Earl of Halifax Collection) & National Gallery (London), Los Angeles County Museum of Art (Los Angeles), Museo del Prado & Museo Thyssen-Bornemisza (Madrid), Palazzo della Provincia (Mantua), Pinacoteca di Brera & Castello Sforzesco (Milan), Alte Pinakothek (Munich), Museo Nazionale di Capodimonte (Naples), Frick Collection (New York), Musée du Louvre (Paris), Fundación Colección Thyssen-Bornemisza (Pedralbes), Accademia di San Luca and Galleria Doria Pamphilj (Rome), Museum Boijmans Van Beuningen (Rotterdam), The Hermitage, (St. Petersburg), Gallerie dell'Accademia & Scuola Grande di San Rocco (Venice, Kunsthistorisches Museum (Vienna), National Gallery of Art (Washington), Kunstsammlungen (Weimar).

indeed something theatrical in direct eye-gaze that partakes of the Mannerist style. Yet Mannerism could not have been the only cause. Direct eye-gaze was on the rise before it, and it remained prevalent in subsequent centuries, long after "Mannerism" had become a term of abuse. Two other events may have played a part: the Reformation started by Martin Luther (1483–1546) and the Catholic revival organized by the council of Trent (1545–1563). Both movements revolutionized the visual world of Europeans — including painters who saw, copied, and made a living painting religious works (McCullough, 2010). Yet, here again, the timing is wrong: direct eye-gaze was progressing, and young painters preferred it, in the earliest decades of the XVIth century. One may note also that the XVIth century gaze shift and its effects were not restricted either to Catholic or to Protestant areas.

A second reason for cautious optimism is the fact that the results of studies 1 and 2 were replicated on a corpus of Korean portraits spanning a period of time that comprises the whole Joseon dynasty (1392–1897) and the early XXth century. In the Korean tradition, averted-gaze portraits were the absolute norm in the earliest periods, but direct-gaze portraits slowly came to prevail. They are also over-represented in a contemporary Korean art book. (See Electronic Supplementary Materials, 1, available on the journal's Web site at www.ehbonline.org, for the two replications.) More replications are needed, especially since Korean portraiture, particularly in its last centuries (were most of the effect is present) was not entirely cut-off from Western influence (although Korea had contacts mostly with China and Japan, where direct eye-gaze in portraits was either the minority or absent).

In other respects, the Korean and European trends are different. It took Renaissance Europe a century to shift to a majority of direct-gaze paintings, while the same shift took at least three times longer in Korea. One explanation could be the importance of norms concerning posing in Korea, where the execution of a portrait was a codified ritual, and treated as such (Sun-Mie, 2010). It may also have to do with the fact that Joseon portraiture was in large part a state monopoly (Sŏng-mi 2008; Sun-Mie, 2010). Renaissance painters, in contrast, typically left their master to set up their own workshop, which then had to face serious competition. The XVIth century saw an increased liberalization of the art trade, with a gradual dismantling of institutions like guild regulations, increasing both revenues and competition (Hauser, 1951). Study 3 suggests that newly established painters, who started their career trying to win new clients while putting up with the competition of better-established workshops, were the force that drove the European shift.

The role of demographic turn-over in cultural changes such as this one deserves further exploration. This mechanism is neglected in most studies of cognitive attraction, which tend to focus on the role of individual memory (Boyer & Ramble, 2001; Norenzayan et al., 2006). Historical linguists, however, have been claiming for a long time that demographic dynamics drive cultural evolution, new learners being the key agents of linguistic change (Lightfoot, 2006; Meillet, 1904). This hypothesis, however, remains controversial in that field (Bybee, 2010, pp. 114-119; Croft, 2001, pp. 44-53). What caused young painters to prefer direct-gaze paintings cannot be said with certainty, but the greater fame that direct-gaze paintings seem to enjoy today suggests that the kind of models that apprentices copied may have played a part. A combination of cognitive attraction, cultural selection and demographic turn-over seems a promising explanation for a variety of cultural changes.

Supplementary Materials

Supplementary material to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2013.01.004.

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