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Auguste Rodin Draws Blind: An Art and Psychology Study

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ABSTRACT

Late in his life Rodin produced many thousand 'instant drawings'. He asked models to make natural energetic movements, and would suddenly draw them at high speed without looking at his hand or paper. To help understand his 'blind drawing' process, eye and hand movements of art students were tracked while they drew blind, copying complex lines presented to them as static images. The line shape was correctly reproduced, but scaling could show major deficiencies not seen in Rodin's sketches. We propose that Rodin's direct vision-to-motor strategy, coupled with his high expertise, allowed him to accurately depict in one sweep the entire model, without "*thoughts arresting the flow of sensations*."

INTRODUCTION

During the last 20 years of his life, the sculptor Auguste Rodin (1840--1917) abandoned somewhat sculpture to produce several thousand wonderful drawings of a special kind which he referred to as his 'instant drawings' (*dessins instantanés*). He would ask his models to move naturally, in any way they wanted, but with energetic and rapid – even acrobatic – movements. He would then suddenly draw them at great speed and without ever looking at his hand or the paper. The resulting pictures were amazing even though they contained the occasional misplaced lines. Nadine Lehni [1], former chief curator at the Musée Rodin Paris, explained to Tchalenko in 2011 what a drawing session with Rodin would have looked like: "*He had always been drawing from imagination, but from about 1900 onwards, he created a completely new way of drawing. Every day, professional models would come to his studio, and Rodin would ask them to be as natural as possible. He never asked them to pose or to take attitudes to convey feelings –-- he was not interested in that. He wanted them to act natural and to have vivid movements: to run, to dance, to comb their hair, to kneel on the floor, etc. Rodin was seated in a chair, a sheet of paper on a cardboard held on his knees and a pencil in his hand. But he was only following the model's movements with his eyes – sometimes one model, sometimes two – and he was looking at them very attentively. Suddenly, amazed by some movement that seemed new to him, or acrobatic or full of vitality, he would seize his pencil and, without removing his eyes a single instant from the model, he would trace at an extraordinary speed the outline of what he saw in front of him. And that was unique, a new process, a very difficult one - in a way, the explanation of the extraordinary*

vitality of his drawings; he was drawing what he was seeing, not seeing what he was drawing".

RODIN'S INSTANT DRAWINGS

Rodin seems to be the only artist to have systematically used blind drawing in this way although teachers of drawing have sometimes advocated a similar 'blind contour' method as a useful training exercises [2, 3]. The instant drawings, first created as starting points for further work, were also amazing as finished sketches depicting extremely complex movements of the human body. At times, however, the drawn line would go out of the paper's boundaries, at which stage the artist would redraw the missing element -- still without looking -- elsewhere on the paper. Figure 1 shows this taking place with the model's left arm and hand. The right arm and hand, possibly the last lines drawn on the paper, are also remarkable but for a different reason: the hand is seen in a clutching attitude, most probably meant for the ankle but missing it by about one centimeter on the paper. This suggests that, having drawn the whole figure essentially in one sweep without looking at the paper, the artist landed the right hand within a centimeter of its intended position. In a comment to his secretary, Ludovici, Rodin explains in 1906: *"Not once while drawing the contour of this form did I take my eyes off the model. Why? Because I wanted to be sure that nothing would distract me from my understanding of the model. Thus not a thought about the technical problem of representing it on paper was allowed to arrest the flow of sensations from my eyes to my hand. Had I looked at my hand this flow would have ceased"* [4].

Although Rodin had been drawing since his youth, the origins of his blind drawing method were situated in his sculptural work. In 1880 he received a commission for the Gates of Hell, a monumental three-dimensional panel 6 m high, 4 m wide and 1 m deep, comprising 180 figures depicting a scene from Dante's Divine Comedy. Rodin worked for a whole year on preparatory drawings from imagination for this work before abandoning the approach, considering that although his drawings did render his vision of Dante, they " were not sufficiently close to reality". He decided to start everything again, working from nature with moving models and modeling each figure directly in clay from life. Pinet, 2006 [5] mentions that he modeled the clay with extraordinary ease, never taking his eyes off the model and forgetting the presence of his visitors who were fascinated to see a face or torso emerge from his hands within just a few minutes. In 1896 his friend, R. Marx, mentioned seeing "a series of drawings no longer done from memory, but using a model" [6]. The first official mention that this method was also centered on the practice of working blind without ever looking at the paper appeared in an article by the art critic Clément-Janin in 1903 [7]. The sculptor had successfully transferred to drawing a working method that he had hitherto reserved for modeling figures, with the aim of capturing the movement of his models without imposing on them the constraints of a classical pose.

Figure 1. Model standing on her right foot while bending her left leg behind her. The model's left arm and hand are out of frame but redrawn further down. In real life, the model's right hand was probably clutching her left ankle, but Rodin's blind drawing caused the hand to miss the ankle by about one centimeter. The right hand's strength-clutch attitude, the left hand's counterbalancing position, the head's tilt and the diagonal shoulders express the body's movement at the verge of instability. Contrast has been digitally enhanced to increase visibility of the initial lines. {D.518_Lores.JPEG}

Ludovici also comments on the possible mishaps when drawing without looking. Referring to the upper leg as it appears in a particular drawing -- possibly the one shown here in Figure 2 -- he wrote: "*I noticed that he kept his eyes fixed on the model, and never looked down at his pencil or the paper on which he was drawing. (…) This way would produce frequent errors: for instance, the final stroke of, say, the right side of a leg, would be brought down so very far wide of the stroke representing the left side that the creature drawn looked as though she had elephantiasis*" [8]. The opposite effect is perceptible below the knee, with a thinning of the lower leg well beyond realistic proportions. In both cases, the error stems from an inaccurate positioning of a line on the picture, the line itself being correct in shape and size. For convenience of description we shall term such instances 'misplacement' errors (see Glossary). It is not know what Ludovici meant when referring to such errors as being frequent, but in the context of the several thousand drawings which are still available today, these errors constitute less than a few percent. Nevertheless, we shall see that they are important for the understanding of Rodin's way of drawing.

Figure 2. The outline of the model's shoulder and back, first drawn blind using a wavy line, is later drawn sighted as a darker 'right line'. The right hand which has gone out of the picture is repeated lower down. The left arm and hand are shown in two consecutive positions, revealing the speed of Rodin's drawing action. The outer contour line of the right leg is misplaced: for reasons unknown to us, the artist seems to have lifted his hand from the paper while drawing the thigh, subsequently starting again too low in the picture. Contrast has been enhanced. {D.5523_Lores.JPEC}

When an instant drawing was finished, Rodin would throw it on the floor and immediately start on the next one. At the end of a session he would pick up the sheets he liked best and, now looking at the drawing, he would reinforce an existing line, or add a darker one, which he referred to as 'the right line' (*le trait juste*). Figure 2 shows this for the model's back. Some drawings would then be retraced and submitted to further changes such as cropping, toning, tinting and collage assembly. Some of the resulting pictures were eventually shown in exhibitions, although the original instant drawings remained private and were only ever seen by a few of Rodin's friends and art critics.

BLIND DRAWING OBSERVED WITH THE EYETRACKER

Previous observations

We have previously reported two types of blind drawing in contemporary art students, which we termed *direct blind copying* and *direct copying* [9]. In the present study we refer to the entity being copied (the psychologist's "stimulus") as the *original* and to the produced drawing as the *copy.* In direct blind copying the original was itself a line drawing

placed on a vertical easel, and the subject was given a sketchpad to hold on his/her lap. The subject was then instructed to copy the original without looking at the sketchpad. Our two principal observations were that perception of the original and drawing of the copy could take place concurrently and that shape was correctly rendered but spatial position and scale were defective. We believe that direct blind copying is what Rodin was doing, although at the time we did not realize this connection. In contrast, for direct copying an original sketch of a cartoon face was copied onto an adjacent paper with the help of gaze shift movements between the original and the copy. In this exercise we observed repeated episodes of blind drawing. As the eye shifted back and forth between original and copy short periods of blind drawing were incorporated into the normal gaze-shift rhythm. For example, the hand would start drawing the copy while the eye was still on the original, or the eye would move back to the original while the hand continued drawing the copy. Our subjects in these eyetracker tests were first year art-school students and they differed in the amount of blind drawing they were using. However, when asked to draw 100% blind, i.e. keeping their eyes only on the original, like Rodin, even the most experienced were prone to severe drawing errors. Typically, having started a blind drawing exercise at one particular scale - say 1 to 1p- subjects would subconsciously change scales during drawing, sometimes more than once. The result would then be a bigger or smaller copy containing further internal size inconsistencies.

The present eye-hand interaction study

In order to gain a better understanding of these drawing errors, and in particular to examine whether they related to Rodin's misplacement errors, we report here a program of eye-tracking tests with a group of 7 art-school students. Each student was asked to perform three direct blind copying tests and three direct copying tests, the latter chosen at three different original-to-copy separations in order to assess whether greater separations introduced more drawing errors. The results of the series of copied drawings were quantitatively compared with the originals using Procrustes analysis [10]- a rigid shape analysis technique that allows separate calculation of shape, scale and rotation accuracies. Following a brief survey of the experimental methods used we describe below the main features seen during direct tracing of an original line, blind copying of lines without vision of the drawn copy, and the more natural direct copying in which the gaze shifts periodically between the original and the copy.

Testing method

Experimental setup

Subjects wearing a head-mounted eye tracker were seated about 55 cm away from a vertical graphics tablet screen. For that distance, 1 degree of visual angle covers a screen area measuring approximately 1 cm in diameter. For right-handed subjects, the screen's left half acted as display monitor containing the original image to be copied and the right

half acted as graphics tablet on which the copy was drawn with a stylus. A scan converter recorded the entire screen continuously as an audiovisual video file (avi) with the eye's position as provided by the eye tracker superimposed as a cursor (that was not seen by the subject) and providing a detailed record of the progress of the line being drawn. Simultaneously, the combined eye tracker and stylus position parameters were recorded as digital data files to be used in the test analysis.

The eye-tracker apparatus used was the head-mounted ASL 501 (Applied Science Laboratories, Bedford, MA) running at 50 Hz. Head position was monitored with an Ascension Flock of Birds magnetic tracker, and the integrated system provided fixation accuracies better than 1 degree. The graphics tablet/monitor was the Cintiq 21UX (Wacom) with a screen size of 432 x 324 mm and a display and recording resolution set at 1024 x 768 pixels. Drawing took place with a stylus directly on the screen. The stylus position was sampled every 40 ms at a resolution of 1 pixel (better than 0.5 mm).

For analysis purposes a vertical line placed mid-way between the original and the copy was used to separate original and copy areas of interest. Original and copy gaze onsets and terminations were then recorded as the eye crossed this central dividing line from which gaze durations could be deduced for the original and the copy sides of the screen. Similarly, the start and end of actual drawing were recorded and blind and sighted drawing durations measured for periods of active drawing when gaze was directed to either side of the divide.

Blind test set up

For the blind drawing situations, subjects were tested 3 times, each time with a different original stimulus. In the blind/occluded tests B1 and B3, respectively the first and last of the series, the original and the copy were 15° apart and separated by a physical visual occluder making it impossible to see the copy, either foveally (in central retinal vision) or peripherally, during drawing. The blind/instructed test B2 was performed without the occluder, the subject being instructed not to look at the copy. The largest separation (30°) was selected for this test in order to make peripheral vision as difficult as possible given the geometry of our experimental set up. Post-test checks of fixation locations from the eye-tracking record verified that these instructions had been followed.

Originals

The original for each test was a complex vertical line 20 cm long made of a succession of 20 simple lines each uniformly curved or straight. Changes in direction from one simple line to the next were always less than ± 90°, which meant that a line never went back on itself. Each copying test was associated with a different original line. All drawing was instructed to proceed from top to bottom of the paper, starting at a pre-marked dot on the copy side of the digitizing screen.

Order of testing

The order of testing was as indicated in Table 1. The series was started with the simplest task – tracing - in order to introduce the subject to the experimental situation. This was followed by the first blind test B1 (with occluder) in what was the subject's very first encounter with the notion or practice of blind drawing. With this test and with its repeat

B3, the actual original to copy distance is theoretically arbitrary as the subject cannot see the copy. The three direct copying tests at different angular separations were grouped together in order to keep the experimental conditions similar throughout. The angles were selected as 30° (maximum of the present setup), 8° (assumed limit of parafoveal vision) and 15° (half way between the two extremes). The last two tests were B2 (blind with instructions) and B3 (blind with occluder), the latter repeating B1 to assess the possibility of skill learning during the earlier tests.

Subjects

The 7 test subjects were 2nd year students at Camberwell College of Arts, University of the Arts London. Five were students in the painting or fine arts course and had experience in drawing from life. For example, subject SS had been drawing quite regularly in secondary school and art college foundation year and was familiar with portraiture, landscape and exact copying. In the analysis which follows, test results will be frequently compared to results from SS whose blind drawing behavior was particularly clear. However this subject was at one extreme of the spectrum in terms of the metrics of the eye and hand. All subjects gave written informed consent to the tests, which had the approval of the local ethical committee.

Accuracy analysis

To compare the accuracy with which the copied line was reproduced from the original we used Procrustes analysis under Matlab (v7.5, The MathWorks Inc.). Procrustes is a rigid shape analysis using a set of linear transformations (isomorphic scaling, translation, and rotation) to find the best fit between two sets of spatial data points. The digital record of each drawn line, and each original stimulus line, was first resampled to 100 equally spaced locations. The two sets of 100 data points were then subjected to Procrustes analysis, to find the linear transformations necessary to best match the copy with the original. We investigated 3 types of error in order to quantify objectively the drawn size, its orientation and accuracy of shape. We defined size as the *scale error* being the absolute departure from perfect (1.0), as quantified by the scaling component. Hence a line drawn scaled by 0.9 or 1.1 compared to the original size would be given a scale error of 0.1, and each would represent a drawing 10% too small or too big. We defined *rotation error* as absolute deviation from perfect (0°), as quantified by the rotational component (maximum=90°), with positive values indicating a counter-clockwise rotation of the copied shape. The *shape error* was then defined as the departure from perfect (0), as quantified by the inverse of the goodness-of-fit criterion, the sum of the squared errors between the two optimally transformed lines, normalized to a maximum of 1.0. All errors were then expressed in percentages.

Eye-hand metrics

We compared gaze and drawing ratios by defining the gaze ratio (G*)* as the ratio of original gaze to copy gaze durations, and drawing ratio (D) as the ratio of drawing time occurring during gaze on the original to drawing time occurring during gaze on the copy [11]. A zero value for D indicated no blind drawing, and a value of greater than 1 indicated more time spent blind drawing than sighted drawing. The amount of blind drawing may also be expressed in terms of a 'blind-to-total' ratio (B) varying between 0% and 100%.

Tracing: Eye-hand interaction tests and accuracy

Tracing over an original line is an entirely sighted task that provides a useful basis for comparing eye-hand interactions and drawing accuracies during blind and gaze-shift tests All subjects were observed to trace over the original line in short strokes broadly matching the simple line structure of the original (Figure 3 left panel, the grey line). Fixations were of the position-lock type (see Glossary) and their timing was systematically ahead of the hand by about one segment. For example, on Figure 3 we see that drawing started with the gaze locked on point 1 while the first line 1 (made up of two segments) was drawn. The gaze then moved to point 2 while the short vertical line 2 was drawn. This was followed by the gaze locking onto point 3 while the curved line 3 was drawn, etc. As expected, errors in tracing were negligible (Table 1): taking 0% as representing perfect accuracy, shape error was 0.2%, scale error 1.2% (i.e. a slight magnification) and rotation error 0.1% (a modest anti-clockwise rotation).

PARAMETER	TRACE	**B1**	8°	15°	30°	**B2**	**B3**
shape %	0.2 (0.3)	1.1 (0.8)	1.1 (0.6)	0.7 (0.4)	1.7 (1.1)	1.7 (0.7)	1.1 (0.5)
scale %	1.2 (0.6)	25.4 (11.4)	1.7 (1.3)	3.5 (0.3)	7 (4.9)	14.7 (8.8)	15.7 (9.3)
rotate %	0.1 (0.2)	6.3 (5.0)	5.1 (4.8)	4.2 (1.7)	3.9 (3.1)	6.3 (3.3)	6.9 (3.6)

Table 1. Mean Procrustes errors of shape, scale and rotation for 7 subjects tracing or drawing complex lines. Tests B1 and B3 were blind copying with the drawing area occluded from view, while B2 was blind by instruction to look only at the original (see text). The 8°, 15° and 30° copying tests allowed the gaze to shift back and forth as the visual angle between original and copy was increased. All data are the means (n=7) with standard deviations shown in parenthesis.

Blind copying: Eye-hand interaction tests and accuracy

In our earlier exploratory study using cartoon faces [13], we had found that the eye generally preceded the hand at the face's main features: nose, lips, chin, etc.. The present tests, using more abstract and complex originals, confirmed that the eye was systematically ahead of the hand by one to four simple line segments, depending on the subject. In the blind/occluded test performed by SS illustrated here in Figure 3 (centre and right), fixations advanced downward along a path roughly bisecting the original line and with the eye ahead by about two simple lines. The visual information required to draw the line thus seemed to be encoded systematically ahead of the rendering hand. Fixations either landed on the original line (e.g. 4, 8, 10, 13) or on points related geometrically to the original line (e.g. 5, 7, 12). In the latter case fixations appeared to be located near the origin of the corresponding arcs. This pattern was common to all subjects with one exception, subject CA who, in this as in all other tests, proceeded very slowly, simple line by simple line, with many repetitions. The blind/instructed tests (B2) that potentially allowed some peripheral

vision produced results in all respects similar to the fully blind/occluded tests, suggesting that peripheral vision was not playing an important part in the drawing strategy.

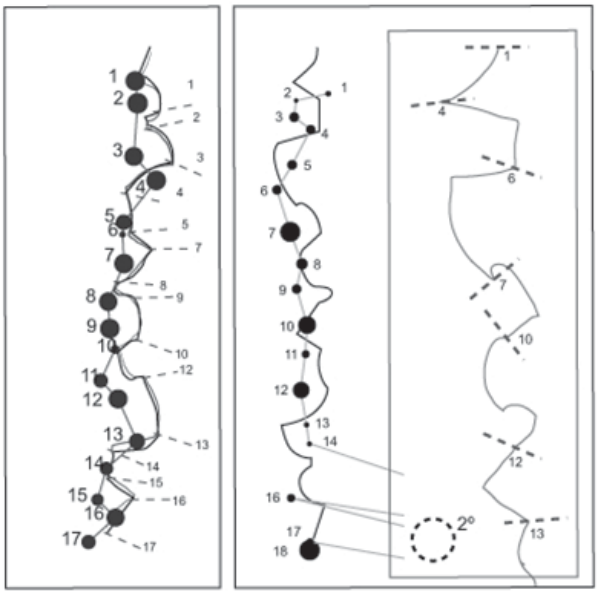

Figure 3. Comparison of subject SS tracing (left panel) and blind/occluded copying B1 (centre and right panels). The original 'to-be-copied' line is shown in black, the copied line, in grey. The numbered black dots indicate the sequence and duration of gaze fixations. The dashed lines indicate, at their intersections with the grey line, the corresponding pencil locations. In the left panel, comparison of the fixation dots with their corresponding pencil locations shows the eye leading the hand as the drawing progresses from top to bottom of the page. In the right panel dashed lines also indicate segment limits where drawing was paused; in this example the full drawn line continues below the level of the original and is not shown in its entirety – note the position of segment 13 on the copy which corresponds approximately to the location of fixation 11 in the central panel. The dashed circle on the right panel gives a scale for both gaze fixation locations (diameter = 2 degrees) and fixation durations (diameter = 2 seconds). Mean drawing time for the entire line was 14.5 s for tracing and 8.0 s for blind copying.
{Figure 5.JPEG}

A visual comparison of the copy line with the original line shows that scale and, to a lesser extent, rotation of the overall image on the paper were manifestly incorrect. In the case of subject SS, the copy size was significantly larger, and the overall rotation was out by a few degrees anti-clockwise (Figure 3 right). The Procrustes analysis summarized in Table 1 confirms these impressions for the whole group: scaling errors were large (mean 18.6%) and rotation errors were also substantial (mean 6.9%). In contrast, shape errors were very small (mean 1.3%).

The scaling errors were significantly different between the six copying tasks (tested with a one way repeated measure ANOVA that excluded the tracing task, $F(2,25)=10.02$, $p<0.001$) and scaling errors increased systematically as original-picture separation increased from 8 to 15 to 30 degrees (linear contrast $F(1,6)=6.55$, $p=0.043$; Figure 5) until they reached the highest level in the blind tasks. The scaling errors did not differ across the 3 blind conditions ($F(2,10)=1.69$, $p=0.23$).

Larger than 1-to-1 scaling errors did in fact characterize all blind copying tests performed here: of the 21 blind experiments recorded, 16 resulted in overall bigger copies and 5 in smaller ones. In the first blind/occluded test (B1) the mean scaling error for all subjects was 25.4% and in the last blind/occluded test (B3) it was 15.7%. The drop in scaling error between the first last blind test could suggest that a learning process was taking place, although further dedicated tests would be needed to confirm this result. With the current sample, the difference was not statistically significant (paired samples t-test, $t(6)=1.42$, $p=0.21$).

However, in the context of the blind and gaze-shift tests described in the present paper, the important observation concerns the magnitude and systematic nature of the scaling errors that accompanied blind drawing amongst our students. In contrast to these scaling errors, rotation errors did not vary significantly across the tasks ($F(5,25)=1.17$, $p=0.3$) while shape errors were very low and also did not vary across all 6 tasks ($F(5,25)=2.33$, $p=0.07$).

Direct copying (gaze-shift copying): Eye-hand interaction tests and accuracy

In the blind tests subjects directed their gaze only to the original. In the direct copying tests, gaze direction was not restricted; all subjects adopted naturally the gaze-shift mode of drawing for which gaze alternated between the original and the copy. Gaze-shifting is by far the most common strategy used when either copying or drawing from life. As explained in a previous section, we used tests with different original-to-copy visual angle separations of 8°, 15° and 30°.

<u>Eye hand interaction pattern</u>

With all subjects, but in varying degrees, drawing took place during both original and copy gazes, i.e. drawing was alternately blind and sighted. The blind drawing ratio B (the time spent drawing blind as a proportion of all drawing time) varied substantially between subjects. For example, in the 15° test, B varied from 80% for subject SS to 10% for CA, with a mean value of 46% over the 7 subjects. In other words, during 46% of the drawing time drawing proceeded blind. Fixations constituting each gaze were organized into patterns varying between the two extremes shown by SS and CA (Figure 4). SS's gaze cycle started with the identification of an original segment (here made up of two simple lines at right angles to each other) with the help of a fixation sequence 1-2-3 during which most of the segment was drawn blind. The cycle terminated as gaze shifted to fixation 4 on the copy acting as position-lock just in time for the hand to finish the segment 1-3. The next cycle then started with the original fixation on 5. The entire eye-hand interaction was based on a quasi-synchronized pattern of eye movements and hand movements punctuated by a succession of fixations on the original followed by a position-lock fixation on the copy. Our assumption is that the fixations located along the original line were part of the visual encoding and spatial referencing of a simple segment of that line; and that the ensuing position-lock fixation on the copy provided spatial reference for the ending of that segment and the start of the next segment.

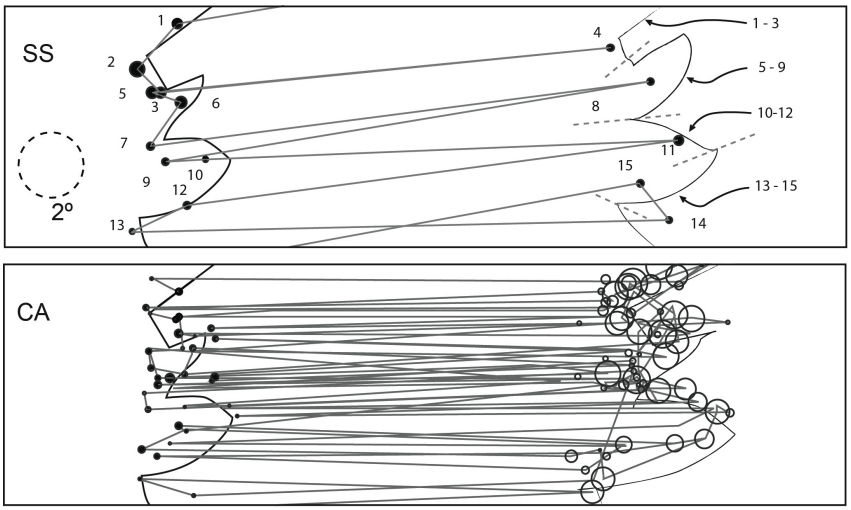

Figure 4. Detailed fixation paths for gaze-shift copying at 15º original to copy separation. The original lines are on the left, and the copied drawing on the right. The numbered circle sizes indicate fixation locations and durations – for clarity these are not filled in the bottom right panel. The dashed circle on the upper panel gives a scale for gaze fixation separation (diameter = 2 degrees) and duration (2 seconds). Drawings from subjects SS and CA are shown, representing the two extremes of behaviour we observed. Mean drawing time for the entire line was 14.1 s for SS and 178.6 s for CA. {Figure 6.JPEG}

CA spent much more time looking at the emerging copy than the original. She worked almost entirely sighted, not segmenting but using the original's simple line-by-simple line structure, often saccading back and forth several times for each simple line. Consequently, her gaze count (the total number of gaze shifts between original and copy) was four to five times that of SS. Typically, after gaze shifted to the copy, CA's hand paused before starting to draw, contributing thus to some very long copy gaze durations. CA presented the extreme case of eye-hand interaction that we encountered in all our eyetracking tests to date.

Amount of blind drawing

In a previous study on the gaze-shift strategy we have shown that blind drawing episodes are built into most gaze-shift drawing situations in variable amounts depending on individual subjects and drawing types [14]. Blind episodes were similarly observed in the present tests with blind ratio B varying between lowest values (12% subject CA) to highest values (80% subject SS) (Table 1). In other words, in tests performed with using the same originals, CA's drawings were essentially sighted and SS's were not far from blind.

Direct copying errors

Table 1 shows that the mean error values for all subjects calculated over the three original-copy separations were insignificant for shape (mean 1.2%), small for scale (mean 4.0%) and small for rotation (mean 4.4%). Changing original – copy separations did not significantly alter these results. The corresponding values for the blind tests had been 1.3%, 18.6% and 6.5%. In other words, allowing a subject vision of the copy avoided most of the scaling errors which had been introduced while the subject was drawing blind. In contrast, shape errors remained very low, and rotation errors were only slightly higher.

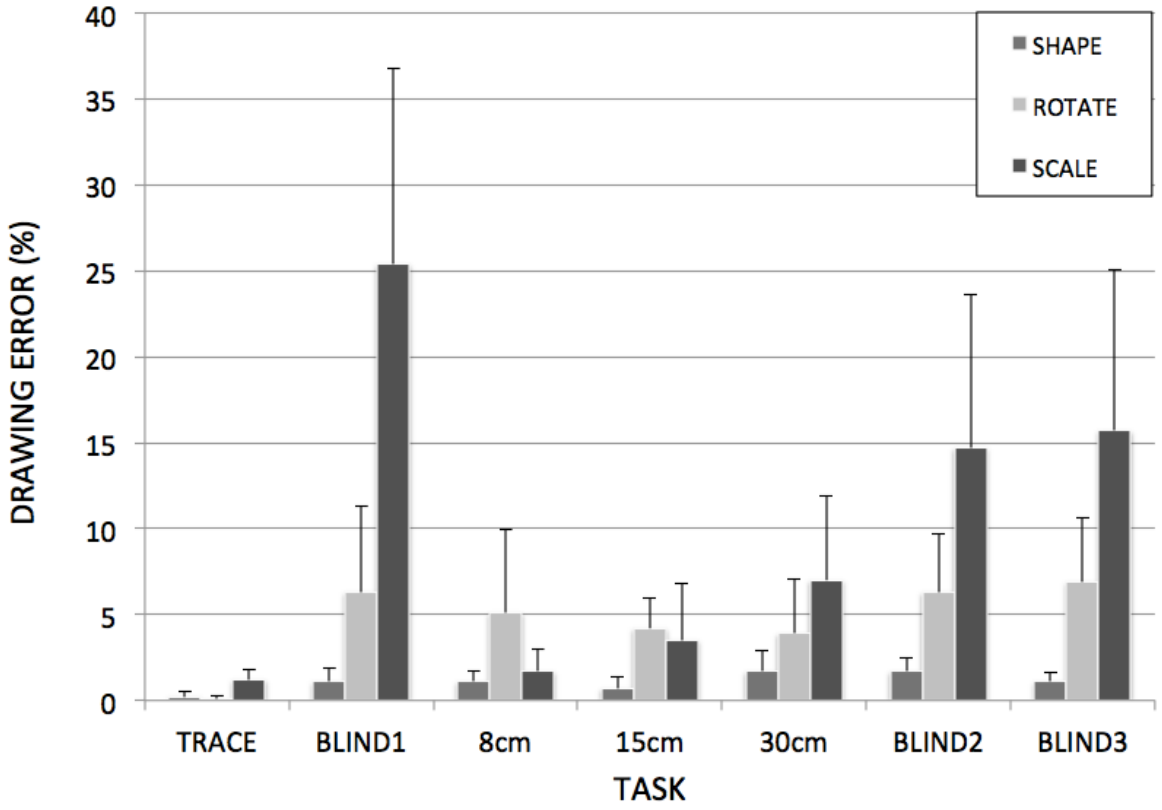

Figure 5. Comparing mean drawing errors for 7 subjects tracing, drawing blind (B1, B2, B3) and gaze-shift drawing at different separations (8°, 15°, 30°). Shape error= grey (left bars); rotation error-light grey; scale error=dark grey (right bars); error bars are standard deviations (1 SD). {Figure B2_amended.eps}

CONCLUSION: ABOUT RODIN'S BLIND STRATEGY

By the end of the last decade of the 19th c Rodin had developed a drawing from life technique whereby he did not look at the picture as he was drawing it. He produced several thousand drawings in this way, many of exceptional dynamic and pictorial quality although a few also exhibited instances of misplaced lines. We found that art students could also copy blind, with only insignificant-to-small shape and rotation errors but with severe scaling errors. These scaling errors would not appear, however, when students were tested drawing in the gaze-shift mode which allowed vision of the copy. Based on the results of a series of eyetracker investigations [15], we proposed a drawing hypothesis whereby the drawing of shape was the result of a visual to motor transformation that could be executed directly while perceiving the original, and without vision of the hand or copy; in contrast, correct spatial positioning of the drawn shape on the copy, including the start and end positions of line segments, required vision of the drawing surface and emerging drawing. Correct scaling being a direct consequence of spatial positioning was therefore not possible when drawing blind. With his instant drawings Rodin had evidently developed a personal drawing strategy to minimize or eliminate altogether the scaling error factor. Further insight into what Rodin was attempting comes from our previous functional brain imaging

work, in which brain activation levels were measured in normal, non-expert drawers who were challenged with various drawing tasks. In one study [16], the pattern of brain activation confirmed previous suggestions that the visual identification and extraction of features in the original image is guided by top-down decisions that depend on frontal cortical areas, strongly influenced by the participant's prior knowledge of the object being drawn, for instance when drawing a face compared to an abstract shape. Rodin's commentary [17] suggests he deliberately sought to avoid this "*technical problem of representing on paper*" by using his instant blind drawing strategy.

A second brain imaging study [18] showed that when visually encoding and subsequently drawing a line-drawn face, where the non-experts were presented with few if any decisions about what to draw, there was a pattern of brain activation consistent with a direct visuomotor mapping during the encoding phase, and no evidence for retention and recall of a mental image. Thus even non-expert artists have the capacity to directly translate visual input into motor actions, but this is normally overlaid by their prior knowledge and judgment, and as this paper shows, is liable to lead to substantial errors in locating the drawn segments on the paper. Rodin was therefore exceptional in both his skillful visuomotor accuracy, and his deliberate elimination of top-down judgment.

Rodin's case is unique in the sense that when drawing blind he not only mastered shape but also scaling. A study of his instant drawings shows that, although he occasionally misplaced lines, as seen for Figures 1 and 2, such errors were quite different to the systematic scale distortions occurring with our subjects. We suggest that Rodin's misplacements were essentially 'one-off' consequences of the exceptional speed at which he was drawing his fast moving models. A contemporary art critic who observed him at work noted: "*In less than a minute, he has captured this snapshot of movement*" [19]. As for the frequent out-of-frame hands or feet, we suggest that they simply indicated his preference for smaller, easier to manage, hand-held drawing boards even if this meant re-sketching the missing element elsewhere on the paper. As mentioned by N. Lehni, 2009 [20], for Rodin, the importance was not to render a perfect static shape but to record his immediate perception of a developing movement, however impetuous or ephemeral that movement might be, and to successfully capture a gesture and attitude hitherto unknown to the history of art.

Apart from drawing very fast we also know that Rodin was drawing without interruption. Ludovici observed: "*The next thing I noticed is that he seemed under some obligation not to lift his pencil from the paper, after having once begun to draw*" [21]. Seen in detail, Figure 2 suggests that the misplaced lines previously noted were consequent to an unscheduled lifting of the pencil while drawing the model's thigh. Whereas most artists slow down or stop altogether between consecutive segments [22], a behavior we also observed in the students' copying tasks, Rodin moved his hand virtually without interruption from the beginning to the end of a drawing. In this way the entire human figure was drawn in one rapid sweep, thus reducing the opportunity of scale changes occurring between the different parts of a drawing. Another recurring feature consisted of the artist using a wavy line, as seen, for example, with the model's left leg in Figure 6 (see also the model's back in Figure 2). The darker line, drawn in a subsequent sighted session, was quite obviously

derived from this initial wavy line. We can only guess at Rodin's intentions: was the wavy line a quick way of indicating the approximate band within which the true line would be defined during the subsequent redrawing stage?

What appears time and again when viewing the instant drawings is that the artist was drawing the movement of the body as opposed to drawing the individual elements composing that movement. For example, in Figure 1, the contour lines of the model's right arm greatly simplify the individual elements of the shoulder, upper arm, lower arm and hand, yet the body's flowing movement from neck to finger tips is perfectly captured. We may speculate that the impression of fast-moving action would have been lost had the artist interrupted his vision of the model in order to visually control the depiction of individual shapes. Instead of segmenting the visual scene in front of him, Rodin unifies it into the continuous movement of his hand. As Dominique Viéville, scholar of Rodin's work techniques, remarks "… *Rodin based his practice on the intuitive impetus transmitted from the eye to the hand, excluding, a priori, all preoccupation with the execution"* [23]. In the artist's own words: *"Je sais pourquoi mes déssins ont cette intensité. (…) C'est que je n'interviens pas. Entre la nature et le papier, j'ai supprimé le talent. Je ne raisonne pas, je me laisse faire..." ("I know why my drawings have such intensity… It is because I don't intervene. Between nature and the paper, I have eliminated talent. I do not reason, I let it happen")* [24].

Figure 6. The wavy *instant* outer line of the model's left leg, at the bottom of the drawing, and the subsequently drawn darker *right/correct* line, illustrate Rodin's procedure: he is more interested in the overall movement that creates the shape than in the individual body element. Contrast has been enhanced. {D.638_Lores.JPEG}

In summary, our analysis of Rodin's technique, supplemented by his own words and the reports of witnesses to his "instant drawing" is consistent with the neural processes we have inferred about visuomotor behaviours in simpler drawing and copying tasks. The eye can capture segments of an observed scene, or drawing, or model, and detailed cognitive decisions can be implemented to allow careful selection of how to represent these on paper [25]. What stands out for Rodin is the extraordinary accuracy of his blind drawings in terms of their scale and position of the drawn shape. In both untrained participants and the art students we have tested, scale and position of the unseen drawing are prone to substantial errors. However, all subjects, even those without any formal training in drawing are capable of capturing and reproducing shape accurately. This direct visual-to-motor transformation may involve minimal prior knowledge of what is being drawn, and may have allowed Rodin to ensure that "*nothing would distract me from my* … visual… *understanding of the model*" - a quote from Ludovici in which we have inserted the word visual [26].

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GLOSSARY

Blind drawing: the act of copying or drawing without looking at one's hand or paper.
Blind ratio (B): the amount of blind drawing time as a proportion of all drawing time.
Complex line: a line made up of several simple lines.
Copy: (verb) reproducing an original line or drawing; (noun) the result of copying.
Copy gaze: gaze directed towards the copy being produced.
Drawing ratio D: the ratio of actual drawing time occurring during gaze on the original to drawing time occurring during gaze on the copy.
Fixation: the maintaining of the eyes steady on a single location. Also used to indicate the point of focus in time and space during which time the eyes are relatively stable.
fMRI: (functional Magnetic Resonance Imaging) is a neuroimaging procedure using MRI technology that measures brain activity by detecting associated changes in blood flow.
Foveal vision: vision using the central portion of the retina responsible for sharp central vision.
Gaze duration: the time during which vision is directed toward a specified region of a scene. A gaze can be made up of several neighboring consecutive fixations.
Gaze ratio G: the ratio of original gaze duration to copy gaze duration.
Gaze-shift: redirecting the gaze from original to copy or vice versa.
Misplacement: an error in locating a drawn line on the paper, without gross errors in the shape or scale of the line.
Original: the external world stimulus (object or image) that is being copied or drawn.
Original gaze: gaze directed toward the original which is being copied or drawn.
Picture: drawn or painted two-dimensional artistic representation.
Position-lock: a stable eye fixation acting as a spatial reference for the drawing hand. A position-lock is generally located in the immediate vicinity of the segment being drawn.
Saccade: a small rapid movement of the eye between two fixations.
Segment: a section of a complex line comprising one or more simple lines and drawn in a single hand movement.
Segmenting: the act of subdividing a complex line into simpler segments.
Sighted drawing: the act of copying or drawing while looking at one's hand or paper.
Simple line: a straight or uniformly curved line.
Target-lock: a stable eye fixation acting as an end point target towards which the hand is drawing.
Visuomotor: the mental processes transforming visual information captured by the eye into movement of the hand.