TECHNICAL ARTICLE

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 he would draw them at high speed without looking at his hand or paper. To help understand his "blind drawing" process, the authors tracked the eye and hand movements of art students while they drew blind, copying complex lines presented to them as static images. The study found that line shape was correctly reproduced, but scaling could show major deficiencies not seen in Rodin's sketches. The authors 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."

During the last 20 years of his life, the sculptor Auguste Rodin (1840–1917) produced several thousand of what he referred to as "instant drawings" (*dessins instantanés*). He would ask models to move naturally but with energetic and rapid—even acrobatic—movements. He would then draw them at great speed, without looking at his hand or the paper. The resulting pictures were proficient even though they contained the occasional misplaced line. In 2011 Nadine Lehni, former chief curator at the Musée Rodin Paris, described such drawing sessions:

> 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 [1].

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RODIN'S INSTANT DRAWINGS

Rodin seems to be the only artist to have systematically used blind drawing, although teachers of drawing have sometimes advocated a similar method as training [2,3]. His instant drawings, first created as starting points for further work, were also notable as finished sketches. At times, the drawn line would exceed the paper's boundaries; the artist would then redraw the missing element—still without looking—elsewhere on the paper. Figure 1 shows this with the model's left arm and hand. The right arm and hand, possibly the last lines drawn on the paper, are also remarkable in that the hand is seen clutching for, most probably, the ankle, but missing 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. Rodin explains to his secretary, Ludovici, 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 youth, the origins of this method were situated in sculptural work. In 1880 he

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Fig. 1. Auguste Rodin, untitled sketch, ca. 1900. 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 actuality, the model's right hand was probably clutching her left ankle, but in Rodin's blind drawing the hand missed the ankle by about one cm. The right hand's clutching gesture, 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 digitally enhanced.) (© Musée Rodin)

Fig. 2. Auguste Rodin, untitled sketch, post-1900. The outline of the model's shoulder and back, first drawn blind using a wavy line, was later drawn sighted as a darker "right line." The right hand, 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: The artist seems to have lifted his hand from the paper while drawing the thigh, subsequently starting again too low in the picture. (Contrast enhanced.) (© Musée Rodin)

received a commission for the *Gates of Hell*, a monumental 3D 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 until, finding them not sufficiently close to reality, he decided to start again, working from moving models and modeling each figure directly in clay. Pinet [5] mentions that Rodin modeled the clay with extraordinary ease, never taking his eyes off the model, forgetting the presence of 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 contemporary reference to the artist's method appeared in a 1903 article by critic Clément-Janin [7].

Ludovici also comments on the mishaps possible when drawing without looking. Referring to the upper leg as it appears in a particular drawing—possibly Fig. 2—he wrote:

> I noticed that he kept his eyes fixed on the model. . . . 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 [as to suggest] elephantiasis [8].

The opposite effect is perceptible below the knee: a thinning of the lower leg well beyond realistic proportions. Both errors stem from inaccurate line positioning, the line shape and size being correct. For convenience we term such instances "misplacement" errors (see Glossary). Although Ludovici called such errors frequent, in the context of the several thousand drawings still available today, they constitute less than a few percent. Nevertheless, we show their importance in understanding Rodin's way of drawing.

Finishing an instant drawing, Rodin would throw it on the floor and immediately start on the next. At the end of a session he would revisit each of the sheets he liked best,

reinforcing an existing line or adding 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—toning, tinting, collage assembly, etc. Some resulting pictures were eventually shown in exhibitions, although the original instant drawings remained private, seen only by a few friends and art critics.

BLIND DRAWING OBSERVED VIA EYE-TRACKER

Previous Observations

We have previously reported two types of blind drawing in first-year contemporary art students, which we termed *direct blind copying* and *direct copying* [9]. Here 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 a line drawing placed on a vertical easel, and the student subject was given a sketchpad to hold on their lap. The subject was then instructed to copy the original without looking at the sketchpad. Our two principal observations: Perception of the original and drawing of the copy could take place concurrently; and 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, in direct copying, the subject copied an original sketch of a cartoon face 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 subject's 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 eye-tracker tests were used to blind drawing to differing extents. However, when asked to draw 100% blind, keeping their eyes only on the original, even the most experienced were prone to severe drawing errors. Typically, having started a blind drawing exercise at one particular scale—say one-to-one—subjects would subconsciously change scales during drawing, sometimes more than once. The result would then contain internal size inconsistencies.

The Present Eye–Hand Interaction Study

To better understand these drawing errors, in particular as related to Rodin's misplacement errors, we report here a program of eye-tracking tests with a group of seven 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 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 with periodic gaze shifts between original and copy.

Testing Method

Experimental Setup

Subjects wearing head-mounted eye-trackers were seated about 55cm from a vertical graphics tablet screen. For that distance, 1° 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; 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 AVI file, with the eye's position as provided by the eye-tracker superimposed as a cursor (not seen by the subject), 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 we used was the head-mounted ASL 501 (Applied Science Laboratories) 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°. The graphics tablet/monitor was the Wacom Cintiq 21UX, with a 432 × 324 mm screen, and a 1024-×-768-pixel display and recording resolution. Drawing took place via stylus directly onscreen. Stylus position was sampled every 40 ms at a resolution of 1 pixel (better than 0.5 mm).

For analysis, we used a vertical line placed midway between the original and the copy 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 copy sides of the screen. Similarly, the starts and ends 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 Setup

For the blind drawing situations, subjects were tested three times, each time with a different original stimulus. In the blind/occluded tests B1 and B3, original and copy were 15° apart and separated by a physical visual occluder, preventing a subject from viewing 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 in order to make peripheral vision as difficult as possible given the geometry of our experimental setup. Posttest checks of fixation locations from the eye-tracking record verified compliance.

TABLE 1. Mean Procrustes errors of shape, scale and rotation for seven subjects tracing or drawing complex lines.

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)

Tests B1 and B3 were blind copying with the drawing area occluded from view; B2 was blind by instruction to look only at the original. 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 in parenthesis.

Originals

The original for each test was a complex 20 cm vertical line 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°: A line never went back on itself. Each copying test was associated with a different original line. All drawing was to proceed from top to bottom of the paper, starting at a premarked dot on the copy side of the digitizing screen.

Order of Testing

Order of testing is 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 its repeat B3, the 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° (halfway 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 seven test subjects were second-year students at Camberwell College of Arts, University of the Arts London. Five were in the painting or fine arts course and had experience in drawing from life. In the analysis below, some test results are compared to results from subject SS, with particularly clear blind drawing behavior at one extreme of the spectrum in eye and hand metrics. All test subjects gave written informed consent, approved by the local ethics committee.

Accuracy Analysis

To gauge the accuracy with which the copied line reproduced the original, we used Procrustes analysis under Matlab (v7.5, The MathWorks Inc.). Procrustes uses a set of linear transformations (isomorphic scaling, translation and rotation) to find the best fit between two sets of spatial data points. We first resampled the digital record of each drawn line, and each original stimulus line, to 100 equally spaced locations. We then subjected the two sets of 100 data points to Procrustes analysis, to find the linear transformations necessary to best match copy with original. We investigated three types of error in order to quantify drawn size, 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 lines drawn scaled by 0.9 or 1.1 compared to the original size of 1.0 would be given a scale error of 0.1, and would represent a drawing 10% too small or too big, respectively. We defined *rotation error* as absolute deviation from perfect (0°, as quantified by the rotational component (maximum=90°), with positive values indicating a counterclockwise 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 >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. We observed all subjects trace over the original line in short strokes broadly matching the simple line structure of the original (Fig. 3, left panel, gray line). Fixations were of position-lock type (see Glossary) and their timing was systematically ahead of the hand by about one segment. For example, Fig. 3 shows 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. Then the gaze locked 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 counterclockwise rotation).

Blind Copying: Eye–Hand Interaction Tests and Accuracy

In our earlier exploratory study using cartoon faces [12], we 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 1–4 simple line segments, depending on the subject. In the blind/occluded test performed by SS (Fig. 3, center and right), fixations advanced downward along a path roughly bisecting the original line, 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, 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 did not play an important part in the drawing strategy.

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, copy size was significantly larger, and overall rotation was out by a few degrees counterclockwise (Fig. 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 also substantial (mean 6.9%). In contrast, shape errors were very small (mean 1.3%).

The scaling errors differed significantly 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° (linear contrast $F(1,6)=6.55$, $p=0.043$; Fig. 4), reaching 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: The 21 recorded blind experiments resulted in 16 bigger overall copies and 5 smaller ones.

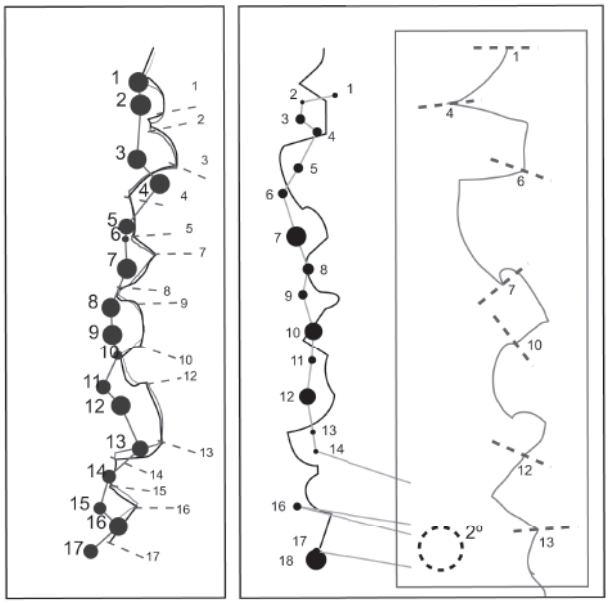

Fig. 3. Comparison of subject SS tracing (left panel) and blind/occluded copying B1 (center and right panels). The original line is shown in black, the copied line in gray. Numbered black dots indicate the sequence and duration of gaze fixations. Dashed lines indicate, at intersections with the gray line, the corresponding pencil locations. In the left panel, comparison of the fixation dots with corresponding pencil locations shows the eye leading the hand as the drawing progresses down the page. In the right panel dashed lines also indicate segment limits where drawing was paused; the full drawn line continues below the level of the original and is not shown in its entirety—the position of segment 13 on the copy 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°) 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. (© John Tchalenko)

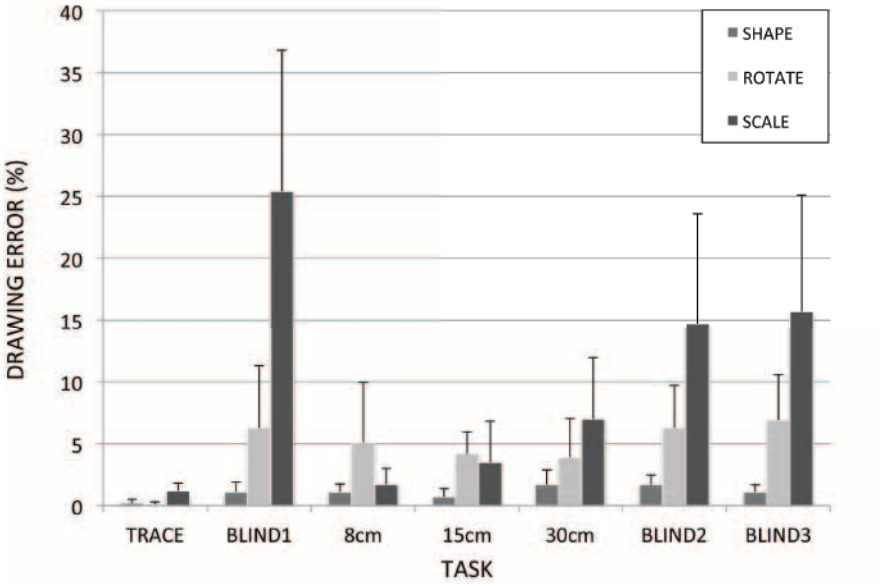

Fig. 4. Comparing mean drawing errors for seven subjects tracing, drawing blind (B1, B2, B3) and gaze-shift drawing at different separations (8°, 15°, 30°). Shape error=gray (left bars); rotation error=light gray; scale error=dark gray (right bars); error bars are standard deviations (1 SD). (© John Tchalenko)

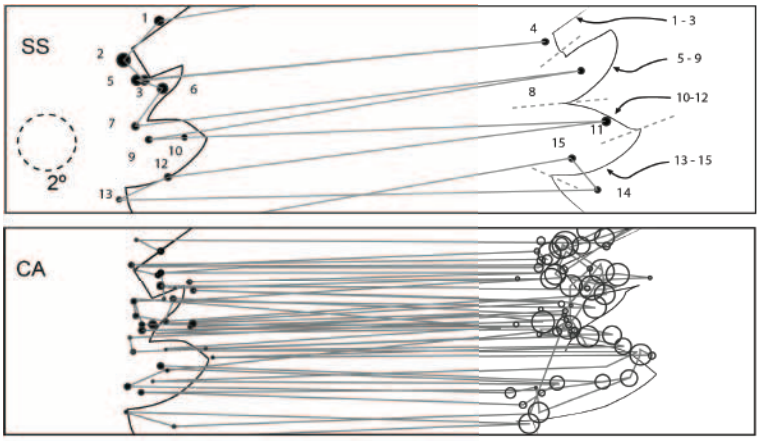

Fig. 5. Detailed fixation paths for gaze-shift copying at 15° original to copy separation. The original lines are on the left, the copied drawing on the right. Numbered circle sizes indicate fixation locations and durations—for clarity these are not filled in the bottom right panel. The dashed circle on the upper panel gives a scale for gaze fixation separation (diameter = 2°) and duration (2 seconds). Drawings from subjects SS and CA are shown, representing the two extremes of behavior observed. Mean drawing time for the entire line was 14.1 s for SS and 178.6 s for CA. (© John Tchalenko)

In the first blind/occluded test (B1), the mean scaling error for all subjects was 25.4%; in the last blind/occluded test (B3) it was 15.7%. The drop in scaling error between the first and last blind test could suggest a learning process, 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, $t(6)=1.42$, $p=0.21$).

In the context of the blind and gaze-shift tests described here, the important observation concerns the magnitude and systematic nature of the scaling errors accompanying blind drawing among our subjects. In contrast to scaling errors, rotation errors did not vary significantly across tasks ($F(5,25)=1.17$, $p=0.3$); shape errors were low and invariant 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 the gaze-shift mode of drawing, gaze alternating between original and copy. Gaze-shifting is by far the most common strategy used when either copying or drawing from life. As explained above, we used tests with different original-to-copy visual angle separations of 8°, 15° and 30°.

Eye–Hand Interaction Pattern

With all subjects, but in varying degrees, drawing took place during both original and copy gazes, alternately blind and sighted. The blind drawing ratio B (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 seven subjects. In other words, during 46% of drawing time, drawing proceeded blind. Fixations constituting each gaze were organized into patterns varying between the two extremes shown by SS and CA (Fig. 5). SS's gaze cycle started with 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 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. We assume 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.

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; we noted saccades back and forth several times for each simple line. Consequently, her gaze count (total number of gaze shifts between original and copy) was 4–5 times that of SS. Typically, after gaze shifted to the copy, CA's hand paused before starting to draw, contributing thus to some long copy gaze durations. CA presents the extreme case of eye-hand interaction in our eye-tracking 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 [13]. Blind episodes were similarly observed in the present tests, with blind ratio B varying from lowest values (12%, subject CA) to highest (80%, subject SS) (Table 1). In other words, in tests performed using the same originals, CA's drawings were essentially sighted; SS's were close to blind.

Direct Copying Errors

Table 1 shows that 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. 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 introduced while the subject was drawing blind. In contrast, shape errors remained very low, and rotation errors were only slightly higher.

CONCLUSION: RODIN'S BLIND STRATEGY

By the end of the last decade of the nineteenth century Rodin had developed a drawing-from-life technique whereby he did not look at a picture while drawing it. He produced several

thousand drawings in this way, many of exceptional dynamic and pictorial quality, although a few exhibited instances of misplaced lines. We found that art students could also copy blind, with only insignificant-to-small shape and rotation errors but severe scaling errors. These scaling errors would not appear, however, when students were tested drawing in the gaze-shift mode that allowed vision of the copy. Based on the results of a series of eye-tracker investigations [14], we proposed a drawing hypothesis whereby shape drawing 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, nonexpert drawers who were challenged with various drawing tasks. In one study [15], 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 [16] 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 [17] showed that when visually encoding and subsequently drawing a line-drawn face, where the nonexperts 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 nonexpert 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 article 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 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 (Figs 1 and 2), such errors were quite different from 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 drew 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" [18]. As for the frequent out-of-frame hands or feet, we suggest that they simply indicated his preference for smaller, easier to manage, handheld drawing boards, even if this meant resketching

Fig. 6. Auguste Rodin, untitled sketch, ca. 1900. The wavy "instant" outer line of the model's left leg, at the bottom of the drawing, and the subsequently drawn darker "right line," illustrate Rodin's interest in the overall movement that creates the shape rather than the individual body element. (Contrast enhanced.) (© Musée Rodin)

the missing element elsewhere on the paper. As mentioned by Lehni [19], for Rodin, the point was not to render a perfect static shape but to record his immediate perception of a developing movement, however impetuous or ephemeral, and to successfully capture a gesture and attitude hitherto unknown to the history of art.

We also know that apart from drawing very fast, 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" [20]. Seen in detail, Fig. 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 [21], a behavior we also observed in our subjects' copying tasks, Rodin moved his hand virtually without interruption from the beginning to the end of a drawing: The entire human figure was drawn in one rapid sweep, thus reducing the risk of scale changes between the different parts of a drawing. Another recurring feature consisted of the artist using a wavy line; see the model's left leg in Fig. 6 (also the model's back in Fig. 2). The darker line, drawn in a subsequent sighted session, was obviously derived from this initial wavy line. Was the wavy line a quick indication of the

approximate band within which the true line would be defined during the subsequent redrawing stage?

Time and again the instant drawings apparently show the artist drawing body movement as opposed to drawing the individual elements composing that movement. For example, in Fig. 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 fingertips is perfectly captured. We may speculate that the impression of fast-moving action would have been lost had the artist interrupted his vision 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" [22].

In the artist's own words:

> Je sais pourquoi mes dessins 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] [23].

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 behaviors in simpler drawing and copying tasks. The eye can capture segments of an observed scene, drawing or model, and careful, detailed cognitive decisions can be implemented in representing these on paper [24]. What stands out is the extraordinary accuracy of Rodin's blind drawings in 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" [25].

References and Notes

1 N. Lehni, "Une Oeuvre dans l'Oeuvre de Rodin," interviewed by J. Tchalenko, Paris, 2011, pp. 21–35, unpublished.

2 K. Nicolaides, *The Natural Way to Draw* (London: Souvenir Press Ltd., 2008, initial copyright 1941) pp. 9–20.

3 B. Edwards, *Drawing on the Right Side of the Brain* (London: HarperCollins, 1993, initial copyright 1979) pp. 84–86.

4 A.M. Ludovici, *Personal Reminiscences of Auguste Rodin* (Philadelphia: Lippincott, 1926) pp. 138–139.

5 H. Pinet, "Comedy or Curtain-Up: Rodin and His Models," in *Rodin, the Figure of Eros* (Paris: Musée Rodin, 2006) p. 14.

6 D. Viéville, " 'Eyes-off' Drawings," in *Rodin, The Figure of Eros* (Paris: Musée Rodin, 2006) pp. 31–55.

7 Clément-Janin, "Les dessins de Rodin," *Les Maitres du dessin* (Paris, 1903) pp. 285–287.

8 Ludovici [4] p. 136.

9 J. Tchalenko and R.C. Miall, "Eye–Hand Strategies in Copying Complex Lines," *Cortex* **45**, No. 3, 368–376 (2009).

10 D.G. Kendall, "A Survey of the Statistical Theory of Shape," *Statistical Science* **4**, No. 2, 87–99 (1989).

11 Tchalenko and Miall [9]; J. Tchalenko et al., "The Gaze-Shift Strategy in Drawing," *Psychology of Aesthetics, Creativity, and the Arts* **8**, No. 3, 330–339 (2014).

12 R.C. Miall, E. Gowan and J. Tchalenko, "Drawing Cartoon Faces: A Functional Imaging Study of the Cognitive Neuroscience of Drawing," *Cortex* **45**, No. 3, 394–406 (2009).

13 Tchalenko and Miall [9].

14 Tchalenko and Miall [9]; J. Tchalenko et al. [11].

15 Miall et al. [12].

16 Ludovici [4] p. 137.

17 R.C. Miall, Se-Ho Nam and J. Tchalenko, "The Influence of Stimulus Format on Drawing—A Functional Imaging Study of Decision Making in Portrait Drawing," *NeuroImage* **102** (2014) pp. 608–619.

18 Clément-Janin [7] p. 286.

19 N. Lehni, "Matisse et Rodin, une passion pour le dessin," in *Matisse Rodin, Paris*, exh. cat. (Musée Rodin, 2009) p. 63.

20 Ludovici [4] p. 137.

21 J. Tchalenko, "Segmentation and Accuracy in Copying and Drawing: Experts and Beginners," *Vision Research* **49**, No. 8, 791–800 (2009).

22 D. Viéville, "Eyes-off Drawings," in *Rodin, The Figure of Eros* (Paris: Musée Rodin, 2006) pp. 31–55.

23 J.E.S. Jeanès, "Rodin," in *D'après Nature: Souvenirs et Portraits* (Paris: Granvelle, 1934) p. 146.

24 Tchalenko et al. [9]; J. Tchalenko et al. [11].

25 Ludovici [4] p. 137.

Glossary

blind drawing—copying or drawing without looking at one's hand or paper

complex line—line made up of several simple lines

copy gaze—gaze directed toward the copy being produced

fixation—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.

foveal vision—vision using the central portion of the retina responsible for sharp central vision

gaze duration—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 shift—redirection of gaze from original to copy or vice versa
misplacement—error in locating a drawn line on the paper, without gross errors in the shape or scale of the line
original—external-world stimulus (object or image) being copied or drawn
original gaze—gaze directed toward the original being copied or drawn
position-lock—stable eye fixation acting as a spatial reference for the drawing hand, generally located in the immediate vicinity of the segment being drawn
saccade—small rapid movement of the eye between two fixations
segment—section of a complex line comprising one or more simple lines and drawn in a single hand movement
sighted drawing—copying or drawing while looking at one's hand or paper
simple line—straight or uniformly curved line
target-lock—stable eye fixation acting as an end point target toward which the hand draws

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