Using Illusory Line Motion to Differentiate Misrepresentation (Stalinesque) and Misremembering (Orwellian) Accounts of Consciousness

John Christie

and

John Barresi

Department of Psychology

Dalhousie University

Halifax, N.S.

Running Head: ILM and Consciousness

Contact: John Christie
Department of Psychology,
Dalhousie University,
Halifax, N.S. B3H 4J1
Canada
email: jjc@mac.com
phone: (902) 494 6551

Abstract

It has been suggested that the difference between misremembering (Orwellian) and misrepresentation (Stalinesque) models of consciousness cannot be differentiated (Dennett, 1991). According to an Orwellian account a briefly presented stimulus is seen and then forgotten; whereas, by a Stalinesque account it is never seen. At the same time, Dennett suggested a method for assessing whether an individual is conscious of something. An experiment was conducted which used the suggested method for assessing consciousness to look at Stalinesque and Orwellian distinctions. A visual illusion, illusory line motion, was presented and participants were requested to make judgments that reflected what they were aware of. The participants were able to make responses indicating that they were aware of the actual stimulus in some conditions, but only of the illusion in others. This finding supports a claim that the difference between the Orwellian and Stalinesque accounts may be empirically observable, and that both types of events may occur depending on task and stimulus parameters.

When watching a magic show consisting of visual illusions we do not generally remember observing the veridical events that lead to the illusion. This is true even though it may be necessary that our visual system process those veridical events in order for us to perceive the illusion that deceives us. When watching a movie where a baseball is seen moving across the skyline, it is important that the individual frames of the movie be processed in order to perceive the motion. But, the frames only present discrete pictures of a baseball in consecutive locations. We never remember being aware of these pictures while observing the "home run". One might question whether this lack of awareness of the veridical events is due to never being conscious of the events that lead to the illusion (misrepresenting), or because the events actually enter consciousness but are quickly forgotten as they are modified into the illusory events (misremembering). It has been postulated that this is an untestable question (Dennett, 1991; Dennett, 1994; Dennett & Kinsbourne, 1992).

Dennett (1991) termed these two views of the way consciousness might function Stalinesque and Orwellian. These terms derive from the nature of the way that Stalin changed and misrepresented information prior to the "show trials", and the way that Orwell envisioned information dissemination in his book 1984 producing a revised memory of the past.

If an illusion is Stalinesque then one is not conscious of the actual events that lead to the illusion, but only of the illusion itself. It is misrepresented such that events are reformulated into the illusion before ever entering consciousness, similar to the way Stalin modified evidence before presenting it in show trials. If an illusion is Orwellian then the perceiver is conscious of the events that lead to the illusion but quickly forgets those events. This is analogous to the way people forgot real events after being told what to think by Big Brother in the novel 1984.

In short, an Orwellian model of the way one perceives illusions is revisionist with respect to consciousness while in a Stalinesque model the illusion is constructed prior to conscious experience. To aid the reader, equivalents will also be used in this article.

Either misrepresenting (Stalin) and misremembering (Orwell), or as the context requires, constructionist and revisionist respectively will be used to denote the two ways of thinking about consciousness.

Dennett (1991: Dennett & Kinsbourne, 1992) claimed that the difference between these two theories was untestable. In Dennett (1991) it was stated unequivocally that,

> "Both models deftly account for all the data – not just the data that we already have, but the data that we can imagine getting in the future... both theorists have exactly the same theory of what happens in your brain; both account for the subjective data – whatever is obtainable from the first person perspective." (p. 124-125)

He later asserted that recognition of the inability to find a difference between these models is fundamental to the Multiple Drafts theory of consciousness that he proposed. That theory will be explored more in the discussion.

Several logical arguments were proposed to support this contention. One of those arguments is that if consciousness is Orwellian then we should experience all of these little temporarily conscious events in a jumbled and confusing stream of consciousness (Dennett, 1994). In this suggestion Dennett neatly ignores a fact, that he points out elsewhere, that things we remember being aware of are few in number (Dennett, 1991). In addition, it is apparent that we can readily forget things that we were once conscious of. Dennett (1994) further suggests that an instantaneous moment of consciousness is absurd. And, we agree. It is highly unlikely that any mental event can be instantaneous. However, we believe that it is an empirical question whether one can be conscious of an event for so brief a period of time that conventional questions closely following the event fail to evoke a conscious recollection about the substance of the event, or even that an event occurred. One cannot claim that an individual was at no time conscious of an event because it cannot be explicitly recalled at a later time.

Even the effort to commit to memory is not sufficient to ensure recall of events that one is definitely conscious of. Decades of research on memory have shown that.

For example, in an experiment used to examine memory for a list of 20 items, one is presented each item slowly, and strongly motivated to memorize each one (for an example see Atkinson & Shiffrin, 1971). The result of such experiments is that items in the middle of the list are not remembered. But, there is no doubt that the individual was conscious of those items and made an effort to store them in memory. Thus, one can have consciousness of an event without subsequent memory of that event. Therefore, testing memory is not sufficient to verify consciousness.

While asserting that the misrepresentation versus misremembering distinction in consciousness was untestable, Dennett also strongly asserted that the question of what one is conscious of is testable. This paper is as much, if not more so, about the methods one can use to test consciousness as it is about the constructionist Stalinesque and revisionist Orwellian distinctions. Noë & O'Regan (2000) have recently provided a criterion for deciding what is, and is not, an event about which an individual is conscious.

> "...for an animal to be "aware" of that to which it is perceptually sensitive is not merely for it to be appropriately coupled perceptually, but for it to integrate its coupling behaviour with its broader capacities for thought and rationally guided action."

This is very similar to Dennett's (1991) metric for deciding whether an event is conscious. In general, conscious events are those about which one can make a rational decision (Dennett & Kinsbourne, 1992, p. 195). We propose (as have Dennett & Kinsbourne, 1992) that prima facie evidence that an event is conscious is that judgments are made about it.

There is a long standing history of this attitude in the psychophysics literature. If a participant is required to make a decision about a specific stimulus in an experiment, then the experimenter may comment on the conscious experience of the participant with respect to properties of the stimulus about which the decision was made. This is strongly implied not only in psychophysics but also in attention literature where

researchers assume that consciousness and attention are the same thing (Posner & Klein, 1973).

Moreover, there is precedent for using the reaction time to a decision about a stimulus as a criterion for whether an individual is conscious of the stimulus. Using a metric of this type, Cowan & Greenspahn (1995) were able to empirically investigate whether consciousness is Stalinesque or Orwellian. They accomplished this by asking subjects to detect the presence of a circle in various locations during an apparent motion procedure.

Apparent motion is an illusion that occurs when a stimulus, a ball for example, is presented in one location, removed, and presented in a second location. The resultant illusory percept is that the ball moved from the first location to the second location through all of the intermediate points even though it never actually existed in any of the intermediate locations. This is the way the illusion of fluid motion is created in film or television, through the rapid serial presentation of still frames.

In Cowan & Greenspahn (1995) there were three locations we will call A, B, and C representing equidistant sequential points from left to right. A circle was presented at location A with a marker at either location B, or C. The circle would be removed and then presented at location C. The observer would perceive apparent motion from point A, through point B, ending at point C. The task was to press a button when the circle arrived at the marker. If the reaction time for detecting the circle at location C was faster than for location B, a pattern that matches the actual events rather than the illusory ones, then the model of consciousness that would best match the results would be Orwellian. The illusory percept involves a misremembering of what was available for conscious judgment. If the reaction to detecting a circle at location B was faster than detection at location C then the model of consciousness that best describes the data is the Stalinesque. The illusory percept involves a misrepresentation of the veridical information that cannot be accessed even when making fast judgments about the stimulus. Cowan & Greenspahn's data supported an Orwellian model of consciousness.

The Stalinesque model cannot explain these data.

However, there were potential problems with the design of Cowan & Greenspahn's experiments. For example, there was no "real" motion condition to compare the results of the illusory motion to. Without a real motion, assumptions about performance in a hypothetical real motion condition remain assumptions. While it may seem reasonable to believe that responses for items presented consecutively will follow a linear pattern in time this is not necessarily so. With very short distances, when alerting effects may have their steepest slope, responses to later positions may be faster than to near positions because the participant has become more alert and prepared to make the response (Klein & Kerr, 1974).

In addition, it is questionable whether the illusory motion that was used would have been truly compelling if it were compared to a real motion illusion. Individuals may have been aware of an item being presented in the final location accompanied by a weak, secondary illusion. This is because the apparent motion illusion used, that of a moving object, generally is considerably weaker when the items are as far apart (3.4°) as in Cowan & Greenspahn's experiments. In fact, Watson, Ahumada, & Farrell (1986) demonstrated that apparent motion and real motion will be consistently differentiated by subjects as the distance between items when they are sampled exceeds 0.12°. In our own examination of displays similar to the ones used by Cowan & Greenspahn we experienced very weak percepts of motion. When compared to real motion they were easily distinguishable.

A final concern with Cowan & Greenspahn (1995) is that they compared performance at the mid point of a movement with that occurring at an end point. It is possible that performance in these locations differs from what would be expected even if there were a real motion. If the circle passes by the marker there is not only evidence that the line has reached the marker, but the additional evidence that it has traveled past it. It might be suggested that detecting movement past a marker should be faster than detecting movement stopped at that marker because motion past the marker is stronger

evidence that the marker has been reached than motion stopped at the marker. Or, one could take the opposite hypothesis and suggest that the extra motion past a marker may interfere with gathering information that the marker has been reached. We know of no clear scientific evidence that helps to decide which effect would be more likely. What is clear is that they are different forms of information and that the differences may have constituted a potential confound in Cowan & Greenspahn's experiments.

In the following experiments we attempt to address several issues in Cowan & Greenspahn (1995) that may have been problematic. Firstly, we used an illusion that is robust through large visual angles. Secondly, we verified the similarity of that illusion to real events. And thirdly, we tested both points within and at the end of the motion over varying distances. We chose Illusory Line Motion (ILM) for our stimulus (Hikosaka, Miyauchi, & Shimojo, 1993).

ILM occurs most typically when an "inducer" is presented prior to the presentation of a line. An inducer may be an onset that occurs adjacent to, or at one end of a line. When an inducer is presented just prior to line onset the line appears to be drawn away from the inducer. Over long distances apparent motion like that used by Cowan & Greenspahn (1995) breaks down and the illusion begins to be perceived as two distinct dots being presented. However, ILM appears strongly over small and large distances. This ability to use larger degrees of visual angle will give the advantage of testing several "mid point" locations against one another rather than needing to compare mid points with end points. Also, the end points of lines of varying length can be compared.

In the following experiments the distinction between Stalinesque and Orwellian forms of consciousness will be explored in a task using a robust illusion. Of significant importance is the fact that the criterion for deciding that the participant is conscious of an event is that they will be able to make a rational choice about that event. Experiment 1 is an assessment of the robustness of ILM while Experiment 2 may be considered a replication and extension of Cowan & Greenspahn (1995).

Experiment 1

In this experiment the similarity of real line drawing and ILM was explored. Subjects were presented with static lines, real motion, and illusory motion at both 4 and 8 degrees in length. The 4° length was included in order to have a comparison to the shorter lines that will be presented in Experiment 2. The subject was required to report whether the line was actually drawn across the screen or the line came on all at once. The participant was informed that sometimes a dot would come on prior to the line but that the dot did not predict whether the line would be drawn across the screen or come on all at once.

One cannot present both the real and illusory line drawing and ask a participant to compare the two because of the inducer. Whether the motion of the drawing looked similar or not would be confounded by the fact that one has the inducer and the other does not. Presenting the inducer with a drawn line would have the effect of adding an illusory motion to a real motion. This appears as a slower motion than either. With the present method and naive participants we can simply suggest that the inducer is irrelevant. No participant spontaneously figured out that there was an illusion and several were very difficult to convince. They believed that the deception was not in the telling that the inducer was irrelevant, but in the description of the line illusion.

Method

Participants

Twelve undergraduate psychology students volunteered for the experiment. Only 10 were used due to equipment problems. They all received one credit point toward their final grade for participation in both Experiments 1 and 2. All 12 students participated in Experiment 1 immediately after participating in Experiment 2. Participants were not debriefed about the nature of the line illusion until after Experiments 1 and 2 were completed.

Apparatus

The stimuli were presented on a Data Check 5010-ACP scope. This was

interfaced through a National Instruments LabLC board into a Macintosh LC 630 computer. This computer and board controlled all timing, presentation, and response collection. A custom 8 bit Z control for the scope was built using 8 of the digital output lines on the board. The Z was adjusted such that at least 200 (out of 256) consecutive points were of equal luminance when viewed through a neutral density filter (wedge). The luminance of all items presented to the participant was within the range of these 200 points.

All drawing on the scope was updated at 500 Hz. A 125°/sec drawing rate was used for the real drawing which resulted in approximately 2 dots of the line presented per refresh. This was a speed selected by the experimenters as one that appeared to be a good match to the speed of the illusory motion presented. The lines were made up of 10 dots per degree of visual angle. The illusory line motion was induced by presenting the first point in the line for 100 msec before the rest of the line was presented simultaneously. When a static line was presented it came on all at once.

The fixation cross was 0.40 degrees across. Lines were either 8° in length or 4° in length and centered above fixation. All real drawing or illusory drawing took place from left to right. A drawing of what the basic display looked like with an 8 degree line (markers used in Experiment 2) can be seen in Figure 1.

There was a display with three possible responses following the line presentation. They were mapped to keys under the first three fingers of the right hand and were "Drawn Line", "Static Line", and "Uncertain".

There were 144 randomly presented trials in total, that were split evenly among the six conditions (24 trials per condition). These conditions were Drawn Line, Static Line, and Illusory Line with 4 and 8 degree lines for each.

Procedure

After the participant was seated comfortably, and the chair and chin rest height adjusted, they were instructed that in this experiment there would be lines presented on the screen. Sometimes the line would be drawn from left to right and other times it

would come on all at once. The participant was instructed to press a button indicating whether the line came on all at once, was drawn left to right, or whether they were uncertain. Participants were told that sometimes a dot comes on shortly before the line; but that this dot was unimportant and was not predictive of whether a line was drawn or came on all at once. This was a necessary deception because the dot never preceded lines that were actually drawn left to right.

Participants were asked afterwards if they felt that they used the inducer to distinguish between lines drawn left to right and those that came on all at once. Participants who confessed to using the inducer for any reason were to be removed from further analysis. Participants were asked questions about whether they perceived anything different about the quality of the lines that were drawn from left to right.

After the completion of the 2 experiments participants were fully debriefed about the line illusion, any deception, and the purpose of the experiment.

Results

Because no participants in this experiment reported using the inducer for the illusory line conditions strategically, all of the participants' results were analyzed. "Uncertain" responses comprised less than 2% of the responses and were found not to differ reliably along any dimensions. These were removed from further analysis. The percentage of "Drawn" judgments for long lines and short lines is presented in Figure 2. A 3 x 2 ANOVA of the percentage of "Drawn" judgment data revealed that there was no difference between judgments for short and long lines, $F(1,10) < 1$, but that there was a main effect of drawing condition, $F(2,20) = 57.8$, $p<0.01$. There was also an interaction between line length and drawing condition, $F(2,20) = 16.2$, $p<0.01$. A Fisher's PLSD (Protected Least Significant Difference Test) was performed, and the results indicate that both drawn and illusory lines differed from the static lines, but that they did not differ from each other, PLSD = 14.6. The interaction is likely due to the increased percentage of "Drawn" judgments for for Illusory 4° lines coupled with a decreased percentage for "Drawn" judgments for Illusory 8° lines.

Participants were asked if they noticed anything odd about the display and the way the lines were presented. They were told that sometimes glitches in the display could occur and we wanted to be certain that there were no artifacts being presented to them. No participant expressed any feelings that the drawn lines looked qualitatively different. However, they did suggest that some lines were drawn across the screen faster than others. Most participants were surprised when the illusory line motion was described.

After being debriefed about the illusion no participant reported noticing that some of the lines were illusory. And, 3 of the participants had to be convinced that the illusion was in fact occurring. They were certain that no illusions had been presented to them.

Discussion

It was found that participants cannot use their memory of an illusory line motion and real line motion to discriminate between them, and therefore rate them both as drawn. However, short lines were more likely to be rated as "Drawn" in the Illusory condition while long lines were more likely to be rated as "Drawn" in the Drawn condition. We suggest that this may be caused by one or both of the following two factors.

Firstly, the inducer may generate a specific duration of motion perception. This may cause shorter illusory lines to appear to be drawn more slowly than longer lines, while allowing the entire experience of the drawing to persist for a constant period. Secondly, in the Drawn Line condition the duration of the drawing experience is briefer with the short line than the long line. This may cause shorter lines to appear to be drawn faster than longer lines even though the velocity is constant. As a real motion becomes faster it becomes more similar to simultaneous onset. It may be that the illusory motion used was perceived as a faster drawing than the real motion used, when the line was long, but a slower drawing than the real motion when the line was short. In any case, the similarity between the Illusory and Drawn Line conditions in contrast to the

very different Static condition supports the notion that participants receive a strong ILM. Furthermore, the similarity supports the experimenters' original subjective experience that the speed for drawing selected is a good match for the perceived speed in the illusion.

Experiment 2

In this experiment a method similar to that used by Cowan & Greenspahn (1995) was employed, but with ILM replacing the more traditional apparent motion. Participants viewed a line being drawn across the screen below an inverted triangle marker. When the line appeared to reach the point of the marker the participant was required to press a button. The time to press this button from the beginning of drawing of the line was used as the reaction time.

In a baseline condition the line came on all at once. The reaction time from this Static Line condition was subtracted from the reaction time scores in other conditions in order that graphs might highlight the differences between experimental and control conditions. In a second condition the line was drawn from left to right across the screen. This was called the Drawn Line condition and was used as another comparison to the test (Illusory Line) condition. It was predicted that relative to the Static condition reaction times in the real Drawing condition would increase as the line was drawn from left to right because reaction times were measured from the moment a line began to come on instead of when it actually arrived at the target location. Finally there was the Illusory condition. A dot in the position of the left most end of the line immediately preceded line onset. While the line was presented all at once it appeared to be drawn from left to right.

In the left panel of Figure 3 the data prediction for a Stalinesque model of perception of the line illusion is presented. If the participant perceives the illusion in a way that is best explained by a Stalinesque theory of perception then performance in the detection task should have a similar slope and timing to the detection of real motion. This is because the only information available to make a conscious decision to respond

will be the illusion. It is possible that this slope will be shallower or steeper than the real drawing condition, depending on how well the illusory motion matches the real motion speed. It is also possible that the line will slope slightly more steeply for the Illusory Line condition due to attention being attracted to the side where the inducer appears prior to line onset. The attention may improve performance on the side the inducer appeared and reduce it on the other side. This effect should be small because it would be competing with the participant's own efforts to maintain attention at the locus of the marker in order to enhance detection accuracy. In no case could the Stalinesque illusion be supported if performance in the right most positions were not some value above the static baseline because both attentional orienting effects and the illusion itself would cause slower performance than the static condition.

The prediction for performance in the present experiment, if an Orwellian model of perception is correct, is shown in the right panel of Figure 3. If the illusory experience is Orwellian then performance in the illusory condition should be similar to the static line performance. Participants will be able to use the early entry of the veridical line presentation into consciousness to make decisions about whether there is a line under the marker, but will quickly forget that information as the illusion is formed. Performance may be somewhat modified by attention being attracted to the inducer, just as with a Stalinesque perception, resulting in a slight slope with faster times closer to the inducer and slower ones farther away. However, again this effect should be very small because it competes with the participant's efforts to maintain attention at the point where the target will appear (the marker location).

Neither of the theories predicts a difference for lines that end at the target location or lines that pass through the target location. If Cowan & Greenspahn (1995) were correct that this is an unimportant factor, then, whichever of these predictions most accurately matches the data that is produced, it should do so equally for conditions where lines end at the target location and where lines pass through the target location.

Method

Participants

The twelve participants of Experiment 1 also participated in this experiment prior to performing the tasks in Experiment 1.

Apparatus

The equipment used, and stimulus presentation were the same as in Experiment 1 except for the following exceptions.

As in Experiment 1 the center of the display contained a fixation cross. There was a marker 0.87 degrees above fixation in one of 4 horizontal locations either 2 degrees to the left of fixation (2°), immediately above fixation (4°), 2 degrees to the right of fixation (6°), or 4 degrees to the right of fixation (8°). Lines were presented horizontally with one end four degrees to the left of fixation and the other end: (1) 4 degrees to the right of fixation; (2) immediately under the marker; or (3) 0.7 degrees to the left of the marker. A drawing of the basic display with markers and an 8 degree line can be seen in Figure 1. In the actual experiment only one of the markers was presented on a trial. The lines could be presented in any of the 3 ways used in Experiment 1.

All lines, except catch trials, reached the target marker location 1 second after the participant initiated the trial with the thumb switch. However, timing for the response commenced at the beginning of line drawing. Therefore, the response times measured are not from the moment the actual target event appeared (line under marker) but for this response time added to the time for the line to reach the marker. This added amount would be 0 in the illusory and simultaneous line conditions but would increase linearly from right to left for the drawn line condition. This method of measurement allows the presentation of the reaction times in the drawn condition to maintain the expected shape.

There were 360 trials in total and 33 conditions. For the first 3 of the 4 possible target positions (2°, 4°, and 6°) there were 3 possible conditions. A target could be present due to a line passing under the target and continuing on to the 8° length, a target could be present because the line terminated under the marker, or a catch trial

could occur where the line stopped just before the marker. For each of these possibilities there were 3 line drawing conditions: Static Line; Illusory Line; Drawn Line. This yields 3 x 3 x 3, the first 27 conditions. They were all equally likely. In the conditions where the target is at the 8° position not all of the above conditions can be satisfied. Specifically, a line can only stop under the marker, it cannot pass on through. At the 8° position there are 2 possible line positions (catch, and under), and 3 possible drawing conditions. This yields 6 conditions with the marker at 8° for the total of 33. There were 10 trials in each condition except at the 8° target present conditions (of which there are 3). At the 8° target present condition there were 20 trials. This insured that all target locations were probed equally often, and that the probability of a catch trial given any one marker position was 0.33.

Procedure

Participants were presented with a fixation point and a marker in one of the 4 positions. When the participant was ready they began a trial by depressing a thumb switch contained in the left hand. After releasing the thumb switch a line, with the beginning 4 degrees to the left, terminated immediately beneath the marker, passed under the marker, or terminated 0.7° before the marker. Participants were instructed to press a button as soon as the end of the line was underneath the marker. When the line stopped 0.7° short of the marker this was considered a catch trial and the participant was required to withhold response. The line stayed on the screen until a response was made or until 1 second had passed.

The experimental block of 360 trials was preceded by a practice block of 72 trials (one fifth of the total) randomly selected from the 360 trials ensuring that the proportion of conditions was kept constant.

Results

False Alarm rates were analyzed first. The mean rate never exceeded 8 %. There was a main effect of marker position where false alarm rates increased as the marker moved to the right, $F(3, 42) = 7.44$, $p < 0.01$. However, there was no main effect of

drawing conditions, $F(2, 28) < 1$, or interaction, $F(6, 84) < 1$. Therefore, false alarm rates increased with line length, but there were no other effects on false alarms.

The reaction time difference from the Static Line condition for target present conditions, where the line was drawn the full 8° length, are presented in Figure 4. In that figure there is no point at which the detection of the illusory line at a location is slower than that of the static line. This data pattern cannot support a Stalinesque interpretation. A 4 x 3 ANOVA revealed that there was a main effect of marker position, $F(3,42) = 7.70$, $p < 0.01$, drawing condition, $F(2,28) = 15.38$, $p < 0.01$, and a marginal interaction between the two, $F(6,84) = 2.00$, $p = 0.07$. Because these were linear patterns a first degree polynomial test of order was performed under which the interaction was significant, $F(1,14) = 7.51$, $p = 0.02$. In order to test what contributed most to the interaction three further ANOVA's were run, each leaving out one of the conditions. It was found that the Drawn condition interacted with the Static condition, $F(3,42) = 3.14$, $p < 0.05$, and marginally with the Illusory condition, $F(3,42) = 2.15$, $p = 0.10$. A linear polynomial test of order for this interaction was also marginal, $F(1,14) = 3.45$, $p = 0.08$. The Static and Illusory conditions did not interact with each other, $F(3,42) < 1$, and there was no main effect between them $F(1, 14) < 1$. From these data we can conclude the the illusion very closely followed the static line condition, and not the real drawing condition.

The difference between the slopes of the predicted and actual performance for the drawn line condition is +0.17 msec/degree; and the relative magnitudes differ by less than 7 msec. These are surprisingly similar.

The reaction time measurements for conditions where the line terminated immediately beneath the marker are shown in Figure 5. These should also follow either the Stalinesque or Orwellian model. These are analyzed separately because of our concerns that Cowan & Greenspahn's (1995) test of a mid point compared to an end point makes the implicit assumption that responding to movement in those two

conditions is roughly equivalent. As can be seen from the data in Figure 5 this may have been a legitimate concern. Real motion where the line terminates at the marker does not follow the linear pattern found when the line passes under the marker and continues to its maximum length. And, the pattern of performance from 2 through 6 degrees is strikingly similar between the real and illusory motion conditions, while at the 8 degree position this is not the case. A 4 x 3 ANOVA revealed that there was a main effect of line length, $F(3, 42) = 3.06$, $p < 0.05$, a main effect of drawing condition, $F(2, 28) = 24.66 < 0.01$, and an interaction between the two, $F(6, 84) = 6.17$, $p < 0.01$. Looking more closely at the 2-6 degree positions, and what contributed to the interaction it turns out that both Drawn Line, $F(2, 28) = 10.60$, $p < 0.01$, and Illusory Line, $F(2, 28) = 4.05$, $p < 0.05$, interacted with Static Line, but they did not interact with each other, $F(6, 84) = 2.03$, $p = 0.15$. Because performance was more similar between the Drawn Line, and Illusory Line conditions than between the Static Line, and Illusory Line conditions these data support a Stalinesque model, at least for the shorter lines. This makes sense given that the data at 8° in Figure 5 are the same as those in Figure 4 which we have already stated follow a pattern predicted by an Orwellian explanation.

An alternative description of the conditions where lines terminated beneath the marker can also be derived. One might suggest that rather than a pattern from the 2 through 6 degree positions emerging as Stalinesque there is really only a single unique point at 4 degrees. If not for that condition a straight line might be drawn from position 2 through position 8 for each of the conditions that mirrors what was found when the line was always 8°. This will be explored in the discussion, but it is important to note that under such an explanation the 4° position still supports a Stalinesque interpretation. In addition, it will be important for a later argument to note that there is no difference across conditions in false alarm rates at the 4° position when the line terminated beneath the marker, $F(1,14) = 1.0$.

Finally, Figure 6 depicts the unsubtracted reaction times for performance in the

Static Line conditions where lines were drawn the full 8° to those where lines terminated immediately beneath the marker. The data for the 8° position is the exact same point for both conditions. It can be seen from these graphs that performance to the simultaneously presented 8° line was faster than the line that ended under the marker. This difference can easily be explained under information processing as a probability effect. While all 8 positions were probed equally often not all line lengths were presented equally often: 5/8ths of the time the lines were 8° in length while the other 3/8ths were divided among the other condition's 3 lengths. The lower probability of a short line should lead to slower reaction times according to information processing theory (the Hick/Hyman law presented in Keele, 1973). The "U" shape of the function can be explained by enhanced processing as items get closer to the fovea. The 4° position was immediately above fixation.

Discussion

This experiment supports both the Orwellian explanation of the perception of the line illusion, and the Stalinesque, but each exclusively and each under specific conditions. When a line is drawn the full length of the screen Illusory Line performance very closely matches the perception of the Static Line, but it is not at all similar to the Drawn Line (which almost exactly matches predictions based on actual drawing time). This is exactly what would be predicted if a revisionist Orwellian model of consciousness prevailed. Moreover, when a line is presented that stops immediately under the marker reaction times to Illusory lines at the 4° position appear more similar to the Drawn Line condition than the Static Line condition. This is a pattern of performance that is predicted by a constructionist Stalinesque model. Therefore, both Stalinesque and Orwellian models of consciousness may be functioning in specific conditions and, more importantly, it is possible to distinguish between them.

We are not certain why there is a Stalinesque pattern of performance at the 4° position when the line terminates beneath the marker. However, we can speculate that this is based on some visual properties unique to this particular condition. In this

condition the termination of the line, the lower point of the marker, and fixation, are all in alignment. That happens in no other condition. What changes this caused we could only guess at. When observing the trials ourselves we could find nothing subjectively unique about this trial other than the fact that the line terminated immediately above fixation. Our tentative, and speculative, explanation for this finding is that because the line ends at fixation, the illusion can be constructed more quickly. It seems necessary that the end of the line be sensed in order to construct the entire illusion. Because the end will be sensed faster at fixation than the rest of the line then perhaps the ILM works in a Stalinesque fashion in that condition.

Alternatively, it may be that there is a pattern of performance for all of the lines that terminate under the marker prior to 8° that is Stalinesque. But, an argument that the data support this is difficult to forward. We instead conservatively choose to suggest that the 4° position reflects a Stalinesque process and the others are questionable, when the line terminates beneath the marker.

What is most important to extract from the above results is that unqualified support for either the Orwellian or Stalinesque model is not found; but that there are results that support both interpretations depending upon the conditions in the experiment.

General Discussion

There are three ways one might wish to approach the present results. The first approach to these data is to interpret them with an information processing perspective and to assert that the concept of consciousness is unnecessary in understanding the data. We regard such a position as a form of theoretical absolutism. That is in effect equivalent to sticking one's head in the sand with regard to consciousness.

The second approach, taken by Dennett (1991; Dennett & Kinsbourne, 1992), would view the data as irrelevant to the issue of whether Stalinesque or Orwellian processes are involved in consciousness because the distinction simply cannot be made. On this view it is a priori impossible to discriminate between the two models regardless

of empirical results. Under this view one must either assert that consciousness was not involved in the judgment or that consciousness was modified by it.

The third position is the one we take. The data do speak to a question about consciousness. Specifically, it has been found that, while keeping everything but stimulus factors constant, an Orwellian model of consciousness may describe the perception of a very powerful illusion in some circumstances while a Stalinesque one will better describe it in others. But, more importantly, it has been demonstrated that it is an empirical question whether any one model best fits any particular illusion in a given situation. And, results have been found that cannot be explained under one of them (Stalinesque); thus refuting Dennett's claim to the contrary (Dennett, 1991, 1994; Dennett & Kinsbourne, 1992).

In what follows our theoretical position that the present data speak to a question of consciousness will be buttressed with logical arguments and further examination of the meaning of the present data. At the same time, it will be explained why the first two positions fail to provide an adequate account of these data.

One may attempt to argue that consciousness was not tested and that the judgment that participants made did not require it. Such a mechanistic information processing explanation is problematic for a number of reasons.

Our initial requirement is that a rational judgment needs to be made about the stimulus. Making a rational judgment is considered something that can only occur if the individual is conscious of the subject of the judgment. One might take a more conservative information processing approach and hypothesize that the performance that appeared to support an Orwellian model in the present data was executed prior to consciousness but that the Stalinesque performance was not. This hypothesis can be tested in the data because one would expect that accuracy should generally be improved in conscious over non conscious responding (cf. Posner & Klein, 1973). Therefore, a criterion shift toward making fewer false alarms should be present when the data supports a Stalinesque model if it alone represents conscious processing. There is

evidence that there was a higher criterion for making responses as the marker moved toward the beginning of the line. But, that did not interact with any other conditions. The criterion for making a response when the performance reflected a Stalinesque process, and when it reflected an Orwellian one, was the same.

Because there was no criterion shift between the constructionist Stalinesque and revisionist Orwellian conditions then one may assume that all responses at a given position were based on a similar quality of information. We know that in some cases there is a Stalinesque like pattern where the illusion was used as if it was the veridical information. And, it is highly unlikely that the responses based on the illusion represent preconscious processing. Therefore, in the conditions where the Stalinesque model is supported it is most probable that conscious processing is being tapped. It then follows that because there is no change in the criterion or error rate for responses between the data that follows a Stalinesque pattern and an Orwellian one, individuals using the veridical information to make judgments must also be using that information consciously. The alternative would be that consciousness had no effect on response accuracy.

In general, appeals to an argument that rational judgments can be made outside of consciousness places one on a slippery slope. It is clear that memory cannot be used as a test for consciousness. One is conscious every day of a variety of events that are forgotten shortly afterwards. And, it is possible to set up some very simple reaction time tasks to function nearly reflexively so that consciousness is not involved in response production. But, those who would contend that willful speeded responses, that require a specific judgment about a stimulus property, are executed prior to conscious processing of that stimulus, or are not consciously executed, leave little room to make empirical inquiries into the timing of consciousness. Other kinds of responses, such as descriptive verbal reports, take far too long to execute and can be updated during their construction. The very nature of a descriptive verbal report is that it relies on memory, which cannot be accepted as the ultimate defining measure of consciousness.

As an alternative to the information processing account, one may attempt to explain the present data using a third model of consciousness, the Multiple Drafts model of consciousness proposed by Dennett (1991; see also Dennett, 1994; Dennett & Kinsbourne, 1992). The framework of this model shares many properties with Selfridge & Neisser's (1960) pandemonium model of perception, but instead of demons there are editors; and instead of merely letter recognition, consciousness is explained. In the Multiple Drafts model it is proposed that whether an event is conscious, or not, is very flexible. Drafts of possible events are constructed in the mind based on incoming data. By changing the kinds of questions asked ("probes"), or the timing of those questions, then which draft achieves conscious status will change. Although Dennett does not make an explicit prediction about what exactly could be demonstrated as conscious, that would help in the present situation, it seems apparent from the model that one may be able to find awareness of the actual components that make up visual illusions by asking the correct questions at the correct time. It is likely that at some point a draft that the line came on all at once was generated.

The Multiple Drafts model has an alternate explanation of the present data. In the Multiple Drafts model it is asserted that there is no Orwellian consciousness (Dennett, 1994) because that would lead to a very odd and jumbled stream of consciousness. It is further asserted, as stated above, that by asking the right kind of question at the right time, one may be able to change the contents of consciousness (a different draft may win). Therefore, using the Multiple Drafts model one may assert that, by asking the participants to make the conscious decision about the position of the line, one has changed the contents of consciousness. It may have been that, because of the response requirements, individuals became aware of the veridical line. If the decision to press the button because the line was beneath the marker modified the contents of consciousness then this may have caused participants to see a static line preceding the illusory motion or the illusion may have been completely eliminated. According to the Multiple Drafts model we have not uncovered a forgotten conscious event but may

have changed the contents of consciousness with our probe and decision requirements.

There is some evidence in our experiments that is inconsistent with that explanation. After both experiments, but before being debriefed, participants were asked if they noticed anything odd about the display and the way the lines were presented. They were told that sometimes glitches in the display could occur and we wanted to be certain that there were no artifacts being presented to them. No participant noticed any artifact such as a static line followed immediately by an illusion, in contrast to the Multiple Drafts model. The only things that were noticed were that some lines, that were drawn across the screen, seemed to go faster than others. We told them that that was perfectly normal. Furthermore, after being debriefed about the illusion no participant reported noticing that some of the lines were illusory. And, three of the participants had to be convinced that the illusion was in fact occurring. They were certain that no illusions had been presented to them. These results are inconsistent with the variations in consciousness that would be expected to occur according to the Multiple Drafts model.

Neither the information processing, nor Multiple Drafts accounts satisfactorily explain the present data. Therefore, we accept an account where reconstructionist Stalinesque and revisionist Orwellian forms of consciousness can occur.

We have attempted to answer two questions. One we have approached with empirical scientific analysis. Can one distinguish between Orwellian and Stalinesque forms of consciousness if they both exist? Our answer is that it is possible. Furthermore, because both types of consciousness have been found, they are not mutually exclusive.

The second question being addressed is whether it is possible to engage in a scientific study of consciousness at all. We have laid out very specific criteria that we have used to study consciousness following the guidelines of logic, theory and method. If the present test is not at least partially satisfactory to study consciousness, what is? Are we forever only allowed to appeal to common sense notions of consciousness and then not be able to find any function for such notions? Or should we develop theories

of consciousness which have functions (e.g. rational judgments) and then accept empirical results that support or refute such theories, regardless of whether they oppose "common sense" or not? Our view is that only the latter position can lead to a science of consciousness.

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Figure Captions

Figure 1. A diagram of the display used in the experiments. In Experiment 1 there were no triangle markers and sometimes the line was centered, but half the length represented. In Experiment 2 one marker would be present on each trial and a line arriving under the marker was a target event. The line would always have the leftmost point in the position indicated (4° left). But, the right point could be as represented (8°), stop under the marker, or stop 0.7° to the left of the marker. This is not drawn to scale, see the text for precise measurements.

Figure 2. This is the percentage of "Drawn" responses to the various line conditions in Experiment 1. A "Drawn" judgment indicates the the observer believed the line to be drawn across the screen.

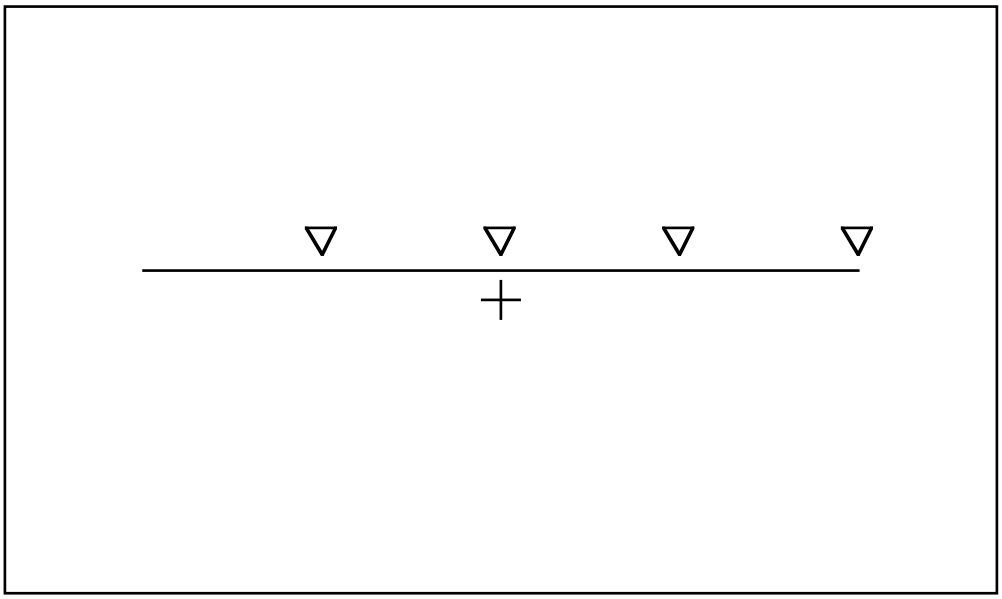
Figure 3. In these two panels the predictions for performance in Experiment 2 can be seen. On the left panel is the prediction for a Stalinesque model of consciousness while in the right panel is the predicted pattern for an Orwellian model of consciousness. Note that the times given are subtracted reaction times with the static line condition as the base. Furthermore, the reaction times are somewhat deceiving because they are measured from when the beginning of the line drawing, not from the beginning of the target event (when the line reaches the marker). This is necessary to make the graphs more readable because without it predictions for performance in the static and drawn line conditions would be the same.

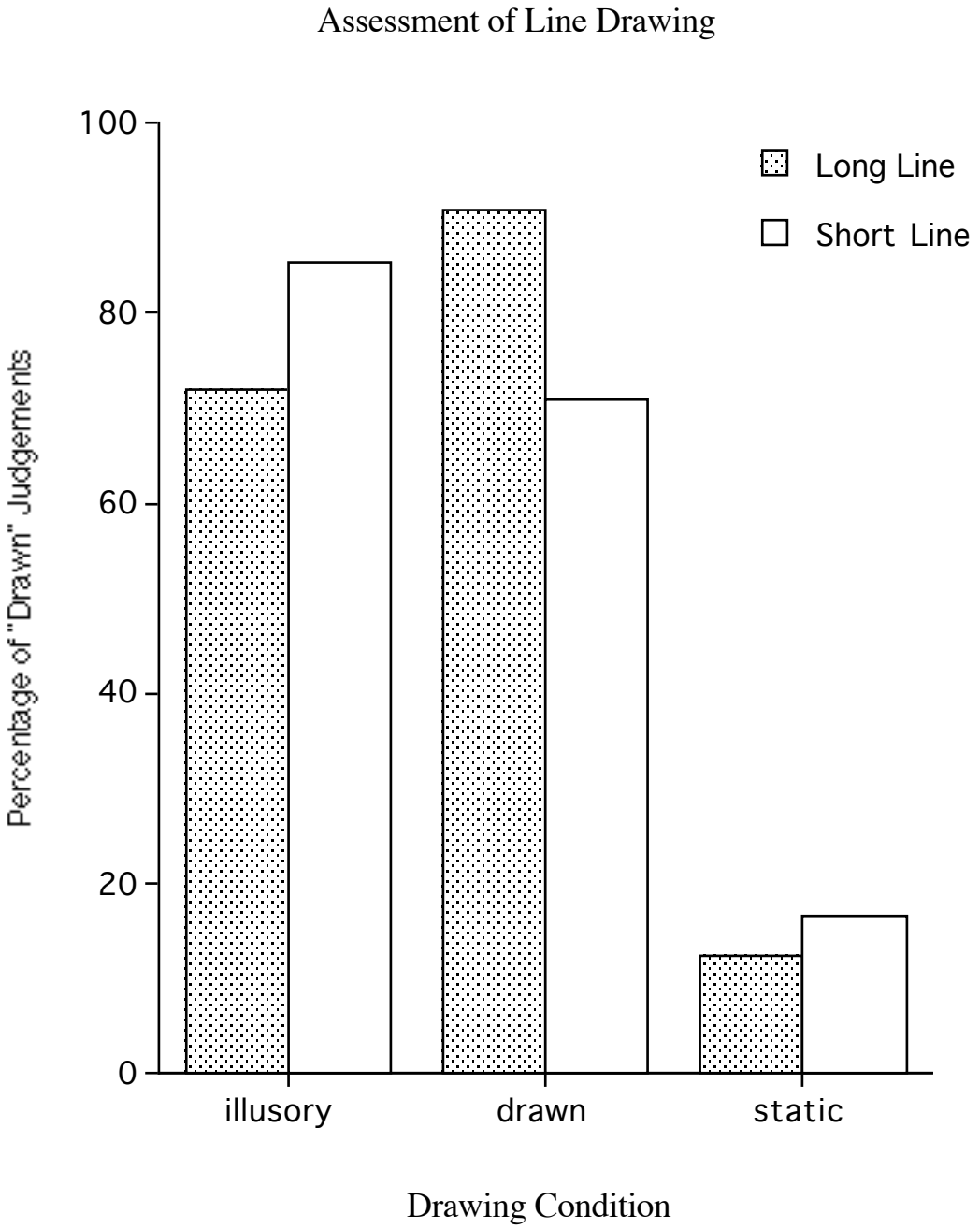
Figure 4. The mean corrected reaction time performance at detecting the position of the line for all participants in Experiment 2 when the line spanned the entire 8°. Performance in the Static line condition is subtracted from all times. Performance that is faster is in negative values while performance that is slower is in positive values. The

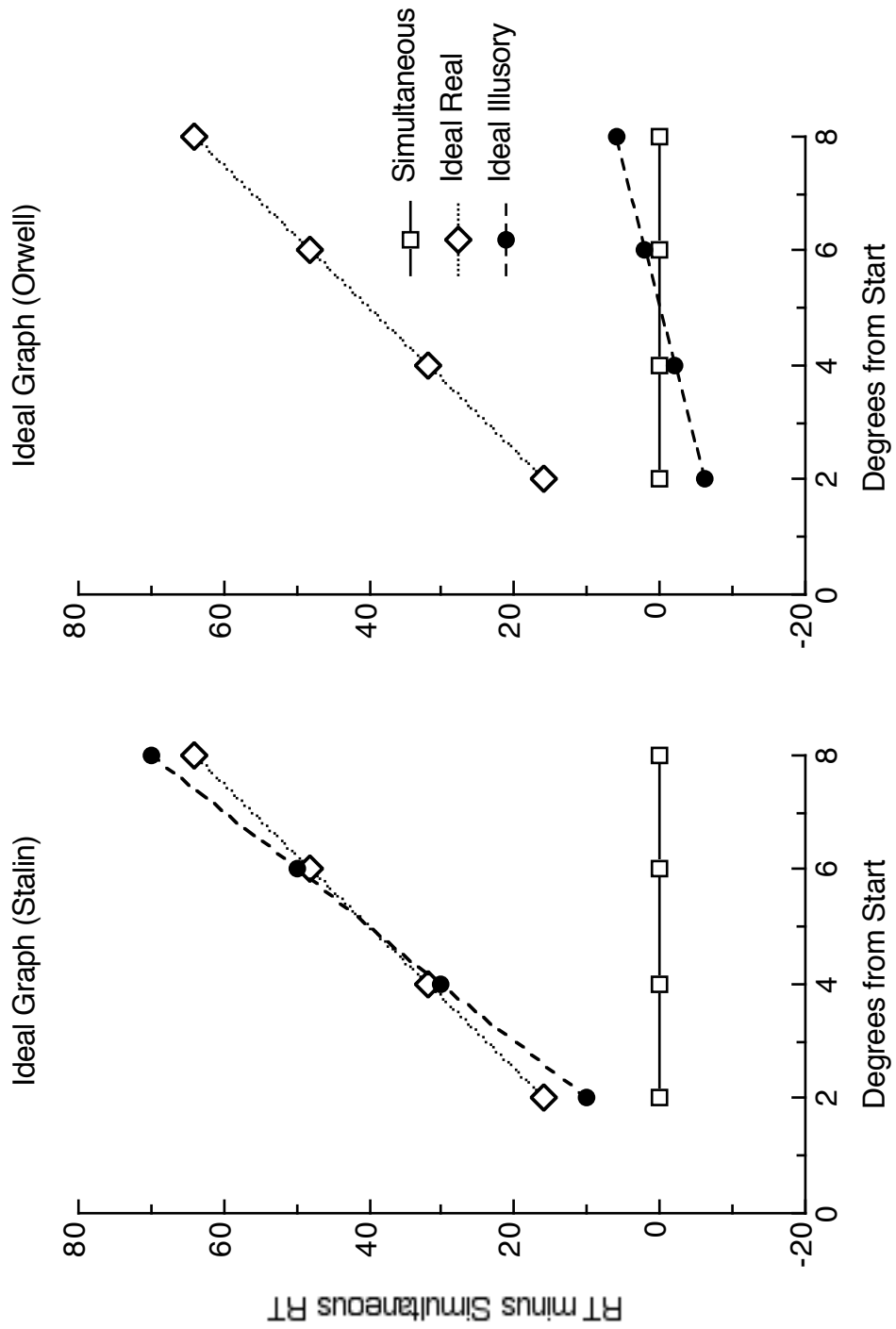
timer was started from the moment line drawing began, not the moment it was under the target marker.

Figure 5. These are the mean corrected reaction time performance at detecting the position of the line for all participants in Experiment 2 when the line stopped immediately under the marker. Performance in the Static line condition is subtracted from all times. Performance that is faster is in negative values while performance that is slower is in positive values. Note that reaction times at the 8° position are from the same data used in Figure 4. The timer was started from the moment line drawing began, not the moment it was under the target marker.

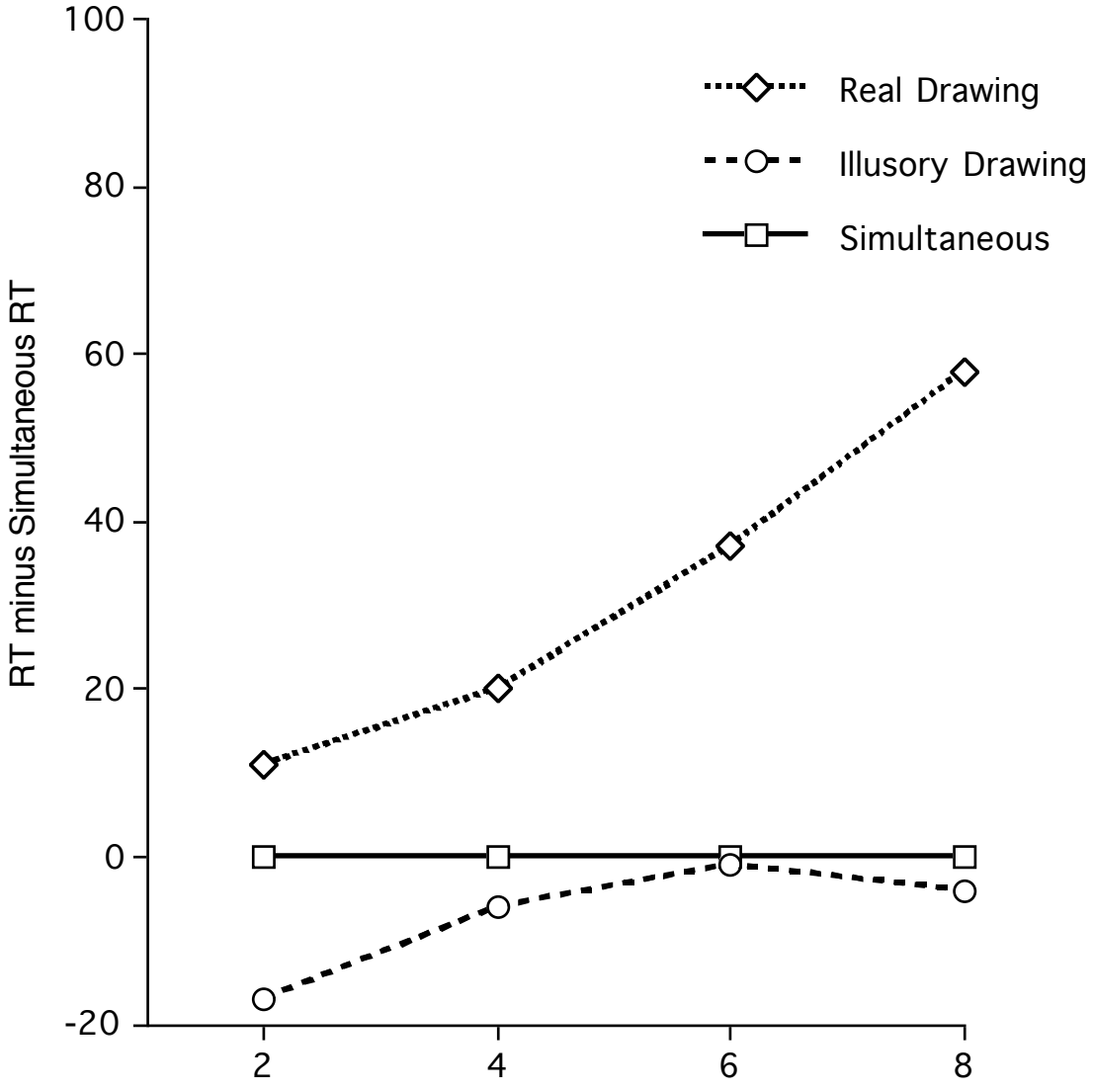
Figure 6. These are the mean reaction times for the simultaneous line presentation conditions from Experiment 2 (the data used in the subtraction scores for the previous figures). The solid line represents conditions where the line was always drawn the full 8° length, while the dashed line represents conditions where the lines terminated immediately beneath the marker. The 8° position represents the same point in both lines since the line is both 8° in length, and terminates beneath the marker.



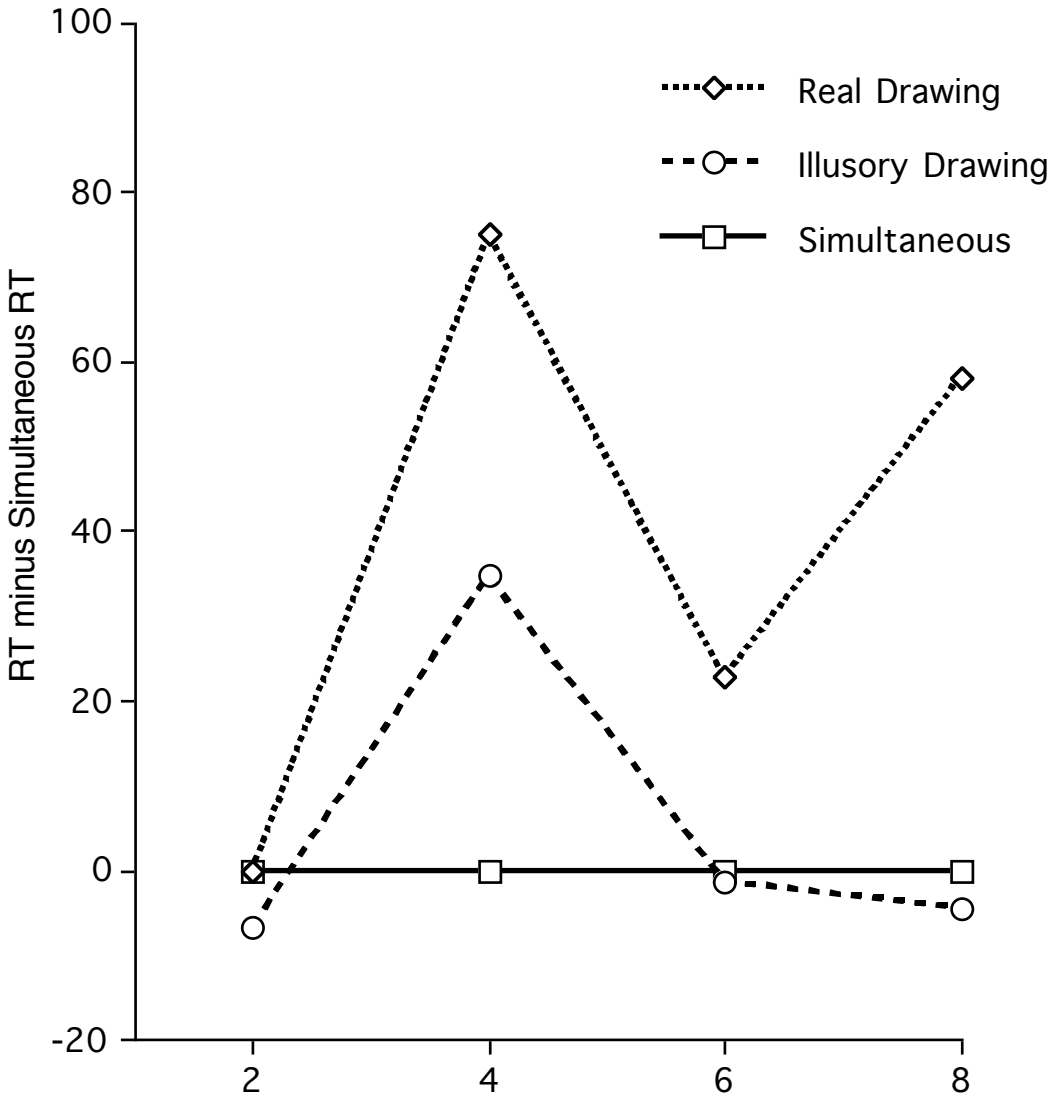

Assessment of Line Drawing
100
80
60
40
20
0
Percentage of "Drawn" Judgements
Long Line
Short Line
illusory
drawn
static
Drawing Condition


Ideal Graph (Stalin)
Ideal Graph (Orwell)
RT minus Simultaneous RT
Degrees from Start
Degrees from Start
Simultaneous
Ideal Real
Ideal Illusory
80
60
40
20
0
-20
0
2
4
6
8

Reaction Times to Lines that Spanned the full 8°



Reaction Times for lines that ended under the marker



Reaction Time Performance in the simultaneous presentation conditions