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Surreptitiously projecting different movies to two subsets of viewers

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A new technique (Manipulation of Overlapping Rivalrous Images by polarizing filters, MORI) was invented for presenting two different images on the same screen that can be seen separately by two groups of viewers without them noticing the overlap. It can easily create desired artificial conflicts among viewers. Two polarizing filters perpendicular to each other provide separate invisible channels from dual video projectors to two groups of viewers via a single screen. The basic principle of the presentation technique, details of the apparatus, and limitations were introduced. As an example of the application of this technique, an eyewitness experiment was briefly reported. The results of experiments conducted by the author and colleagues provide evidence of the effectiveness of this technique with various projectors, video materials, group sizes, and ages of participants.

In conducting psychological studies, researchers may wish to present two different stimuli to two groups of participants to create conflict among them. For example, in the field of social interaction and influence, to gauge factors such as conformity to a majority, obedience to authority, rebellion, etc., researchers must introduce some conflicts among the participants one way or another. It is more convenient for the researchers to create a conflict during experimental sessions and observe how it will be solved, as opposed to using participants who already have existing conflicting opinions among themselves. Discrepancies among a group of viewers can be treated as a kind of error. If one of the viewers observes something different from that observed by the rest, it practically works as a misperception. At the very least, the majority of viewers tend to think that the one who observed a different thing must have misperceived it. Humans are prone to making mistakes. Therefore, human error has been a major research topic in psychology (e.g. Reason, 1990). However, it is rather difficult to observe incidental errors constantly in the laboratory setting. If two different versions can be presented secretly to the viewers, the experimenter can create an artificial misperception systematically in the laboratory. There are some practical applications, especially in criminal investigations and/or judicial procedures involving eyewitnesses whose reports conflict with each other due to either one's misperception or faulty memory. Is it possible to determine which one is reporting correctly? To do so it is necessary to have some fundamental knowledge as to what happens if two eyewitnesses observe the same event differently or report differing recollections.

Social psychologists have used some confederates in their experiments to purposefully create misperception. One of the best-known experiments (Asch, 1958) concerning misperception and conformity used a group of confederates to show that the participants tended to conform to the group consensus. A recent example of research into children's eyewitness testimony (Goodman, Tobey, Batterman-Faunce, Orcutt, Thomas, Shapiro, & Sachsenmaier, 1998) used an unfamiliar male confederate in a play session with child participants, finding that older children were more accurate witnesses than younger children, although older children tended to produce more inaccurate information in free recall. However, using confederates in an experiment has several shortcomings. For example, participants are not so naïve as to be fooled by them easily. It also restricts experiment design. It is difficult, though not impossible, to vary interpersonal relations among 'participants,' or among real participants and confederates. It could be rather easy to make an unfamiliar pair with a participant and a confederate, but difficult to make a familiar pair using a confederate. It is also very hard to find a good child confederate. A better method was needed.

Various techniques for presenting two different images simultaneously have been developed in relation to three dimensional (3-D) display (stereoscopic) techniques. One of the most primitive ones is to use two color filters, such as red and green, to view two overlapping pictures printed in green and red. Using this method, two groups of viewers wearing either green sunglasses or red sunglasses can observe two different versions printed in either red or green respectively on the same screen. However, viewers can readily notice the difference between the glasses they wear, which allows them to figure out easily the difference in what they are shown. It has another shortcoming in terms of the limitation of color.

More sophisticated equipments can be conducted by presenting two different images separately to two eyes to create stereoscopic vision. For example, two video images presented alternately in a rapid succession can be seen separately through

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goggles with high-speed LCD shutters synchronizing to only one of the two. With such equipment, two full-colored video images can be presented quasi-simultaneously AND separately to two viewers sitting side by side rather than to two eyes of a single viewer. Since the goggles are only different in their synchronization, it is impossible for the participants to tell the difference between the two types of goggles they wear. However, it is more likely that they will correctly attribute any discrepancies to the sophisticated equipment rather than to their "misperceptions."

A simple technique is needed to avoid making participants suspicious about tricky presentation. Since human eyes cannot detect the direction of polarized light, polarizing filters are suitable for psychological experiments. There are several advantages to using polarizing filters. Polarization does not affect color perception. In addition, two pairs of sunglasses with different polarizing directions not only look identical, they look just like ordinary sunglasses. Participants are less likely to suspect that any presentation tricks are being introduced in a pair of ordinary-looking sunglasses. Therefore, using polarizing filters instead of color filters can overcome those shortcomings stated earlier. It is also advantageous that polarizing filters are not so expensive.

The purpose of this paper is to introduce a technique using polarizing filters to present two different images on the same screen that can be viewed separately by two groups without them noticing the overlap. First of all, the basic principle of the presentation technique is introduced. Then, details of the apparatus and filming methods are presented. Lastly, an application of this technique in an experiment is briefly described to provide some empirical evidence to support the usability of the technique.

THE MORI TECHNIQUE: A NEW PRESENTATION PROCEDURE

Purpose of the MORI technique

The purpose of the new technique was to meet the following requirements. In order to create conflicts between two groups of viewers, it is desirable to present two different movies simultaneously AND separately to two groups of viewers attending the same presentation session. The procedure must be simple enough to prevent the participants from becoming suspicious. It is also advantageous if it can be used for a variety of psychological experiments including those with child participants.

Basic principle

The MORI (Manipulation of Overlapping Rivalrous Images by polarizing filters, MORI) technique uses the polarization properties of light, which is also used in certain types of 3-D display. Physically speaking, light is a transverse wave, vibrating perpendicular to its direction. The polarization of light is the direction in which the wave is vibrating. Usually, light comprises all polarizations. A polarizing filter allows through only the light of one polarization. Therefore, once light passes through one of these filters (it is then said to be "polarized"), it cannot pass through another polarizing filter placed perpendicular to its polarization (See Figure 1). If two images are polarized in the directions perpendicular to each other and projected onto the same screen, these two images look overlapped to the ordinary eye. However, if a viewer wears a pair of polarizing sunglasses, only one image is seen while the other image is filtered out.

The MORI set-up

In the MORI technique, two different images presented on the same screen can be seen separately by two groups of viewers without them noticing that there are differing, overlapping images. Two video projectors, hidden behind a half-transparent screen, project polarized images that are perpendicular to each other. Participants wear a pair of polarizing sunglasses, which look similar to ordinary sunglasses but can filter out one of the projected images (see Figure 2). Since polarization of light has no effect on human color or motion vision, any material can be presented in full color using the MORI technique without changing its visual characteristics.

One important point should be noted. The filtering of light by a pair of polarizing filters can be achieved as long as the filters are placed exactly

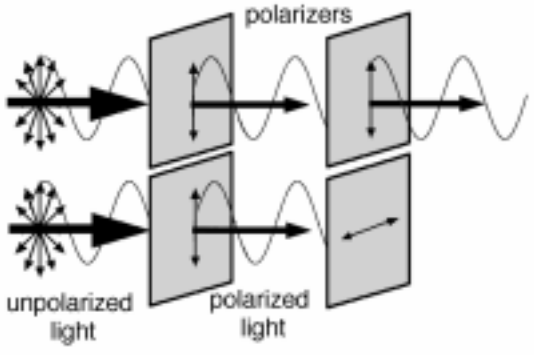

Figure 1. Polarization of light

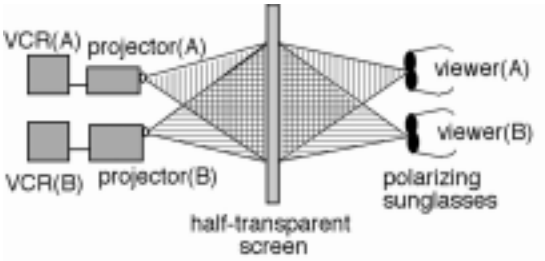

Figure 2. Overall setup of the MORI technique

perpendicular to each other. However, if either of the filters is tilted, the filtering is imperfect. Filtration stays in a narrow range of around 80 to 100 degrees, or 90 degrees plus/minus approximately 10 degrees, depending on the contrast and clearness of the image. This means if either filter is tilted more than 10 degrees, the two images are seen overlapped. Participants wearing polarizing sunglasses may occasionally tilt their heads more than 10 degrees during the presentation. Then, they would see both images, and they would notice that there are two different images being presented simultaneously.

There should be several remedies for this. Adjustment of the timing of two projected movies is very important. If two movies are synchronized perfectly, two overlapped images are unified into one on the screen during most of the presentation. Discrepancy appears only at certain points where the experimenter has secretly inserted some variables. It is during this short period that participants might detect the duality accidentally by tilting their heads. The smaller the proportion of discrepancy, the less the chance of the duality being detected. Therefore, adjustment of movie timing is important. The clearness of the images, which depends mainly on the illuminative power of the projectors, affects the possibility of the appearance of "hidden images." The brighter and clearer the projection, the greater the chance of revealing the hidden images. Of course, there is a trade-off: if the images are not clear enough, the presentation itself is of no use. Experimenters should adjust the level of brightness according to the research objectives. A simple instruction about not tilting the head during the presentation seems effective. However, too much emphasis on 'not-tilting-the-head' might stimulate participants' curiosity causing them to test out the prohibited style of viewing. Instructing the participants to sit up straight during viewing may be more natural and unobtrusive. As will be noted in the evaluation section, the combination of the above treatments prevented the detection of duality in actual applications. No participants figured out that there were actually two different images presented during a series of experiments with more than 300 participants conducted by the present author and other researchers.

Apparatus

Video projectors. Ordinary video projectors can be used for the MORI technique. There are at least two types of projectors on the market today: LCD (Liquid Crystal Display) projectors and DLP (Digital Light Processing) projectors. The light beam of an LCD projector is already polarized because it passes through a set of LCD panels within the projector. An LCD panel is composed of a matrix of small units of liquid crystals sandwiched between two polarizing filters. Therefore, an LCD panel acts as a polarizing filter.

Color video projectors contain three LCD panels for RGB (red, green, and blue) lights. In order to block all three projected beams of light with a polarizing filter, the directions of polarization produced by these three LCD panels must be identical. One of the two types of LCD projectors currently available, those in which the LCD panels are placed in different directions, is not suitable for this presentation technique. On the other hand, the type of projectors whose LCD panels are aligned is suitable for the MORI technique. The two types of projectors can be distinguished by placing a polarizing filter in front of the projection lens and rotating it perpendicular to the projection line. If the three LCD panels are placed in the same direction, the projected image is totally blocked at certain point during the rotation of the filter. It not, the image turns pinkish or greenish but is never blocked totally. If LCD projectors are to be used, the appropriate type should be selected.

A new type of color projector, known as the DLP projector, emits an ordinary unpolarized light beam. A pair of DLP projectors can be used in the MORI technique by placing a polarizing filter in front of each projection lens, so that the pair of polarizing filters makes the light beams polarized and perpendicular to each other. ("DLP" and "Digital Light Processing" are trademarks of Texas Instruments Co. Ltd.)

Half-transparent screen. It is recommended to use a half-transparent screen and to project from the rear because of the following two reasons. First, ordinary screens tend to depolarize the polarized light beam at reflection whereas half-transparent screens let the polarized beam pass through relatively unchanged. Second, rear projection can hide the two projectors from viewers. A plain ground glass pane can be used as a half-transparent screen.

The images projected onto a half-transparent screen can be seen clearly from a right angle plus/minus about 20 degrees. It is not recommended for viewers to watch from angles wider than 30

degrees against the vertical line from the screen. Suitable viewing distance depends on the size of the screen and the resolution of the projector, as well as the research objectives. Generally speaking, a suitable viewing area is from two to five times the diagonal size of the screen.

Polarizing sunglasses. Polarizing sunglasses can be made using ordinary sunglass frames and cutouts from a sheet of polarizing filter. Plastic sheets of polarizing filter are available at a cost of about US$75 for a 1 mm thick sheet of 30x30 cm. To be fitted for sunglass frames, a 1mm thick sheet is recommended. Although it can be easily cut with ordinary scissors, opticians do the framing job much better than laymen.

Preparation of contents

Sideways video filming. In order to produce two perpendicularly polarized images using two LCD projectors, one of them must be set sideways. This means that the images for the projector must be filmed sideways to be projected in the upright position. Sideways video filming can be done easily by simply turning the video camera 90 degrees at the time of recording. Because the frame shape of an ordinary video camera is a 3:4 wider rectangle, sideways filming yields a vertically long frame. The two images are then overlaid on the same screen to produce a square-shaped intersection. Therefore, in both ordinary filming and sideways filming, targets should be framed in the center. It is recommended to use a tripod while video recording. If a ready-made movie is to be used for the presentation, digital movie editing software such as Adobe After Effects can convert ordinary angled movies into sideways ones. As for DLP projectors, sideways video filming is unnecessary.

Presentation contents. Although it is possible to present two different images using the hardware mechanism of the MORI technique, the contents should be prepared carefully. It does not seem possible to make the viewers believe that they were shown the same material at post-viewing conferences if they were shown totally different movies. It is recommended to insert only a small number of differences within the same basic contents.

As stated above, the blockage of the other image by polarizing sunglasses may be interrupted occasionally due to participants' accidental tilting of the head. In order to minimize the possibility of participants noticing the duality of presentation, the two versions of video images should be edited as closely as possible in time and space. Digital video editing software, such as Adobe Premiere, is useful for preparation of video contents.

AN EXAMPLE OF AN APPLICATION

Following Loftus' pioneering study (Loftus, 1979), eyewitness testimony has been a popular research topic in applied cognitive/social psychology (e.g. Dunning & Stern, 1994; Gonzalez, Ellsworth, & Pembroke, 1993; Krafka & Penrod, 1985; Sheehan, Statham, & Jamieson, 1991). Loftus found that memory of an event could easily be distorted by questioning that follows the presentation of the event. However, it is not possible to disentangle distortions in the memory of witnesses from those in reporting of the event within the Loftus paradigm. If the experimenter can intentionally control what a witness observes irrespective of other co-viewers' observations, the witness' perception, reporting, and memory in various social contexts can be investigated.

Kanematsu, Mori, and Mori (1996/2003) applied the MORI technique in an eyewitness testimony experiment. They carried out an experiment in which 30 pairs of undergraduates observed two movies of basically the same event with three contradictory points secretly inserted using the MORI technique. Each pair of participants was instructed to act as eyewitnesses of a criminal event that happened in the dark. Therefore, they were told to wear sunglasses to observe the videotaped event. They were asked to report individually on what they had seen just after the presentation. Then they were allowed to discuss the event they had just observed. Fifteen pairs of participants were instructed to come to an agreement to make a unified report whereas the other fifteen pairs were instructed to discuss what they had seen and to report again individually. Participants were invited to come to the laboratory a week later to report what they had seen the week before. At the very end, they were asked whether they had noticed the fact that they had seen two different versions.

Description of the apparatus

Video cameras. Two versions of a simulated criminal event were recorded using a Sony Handycam Video Hi8 (CCV-TRV91). The same types of video cameras were also used for playing the tapes.

Video projectors. Two LCD video projectors (JVC PD-V7) were used. Each had a 0.7-inch LCD panel with approximately 100,000 pixels. The illuminance of the projection lamp of 12v 30W was approximately 15 lx. Both projectors were mounted on tripods and set side by side behind a half-transparent screen.

Half-transparent screen. A 20cm x 20cm plain ground glass pane 5mm thick was used as a half-transparent screen. It was mounted on a 180cm (height) x 90cm (width) x 5mm (thickness) wooden

panel which had a 20cm x 20cm window in the middle for the screen. Two versions of video images were projected onto the same half-transparent screen. Because one of the video projectors was placed sideways to make its polarized image perpendicular to the other, the intersection of the two images became a square of the shorter side of the two rectangles. Therefore, the screen shape was a square rather than a regular 3:4 rectangle.

Polarizing sunglasses. Two types of polarizing sunglasses suitable for viewing either of the video images were ordered from opticians. They were made using ordinary sunglass frames and cutouts from a sheet of polarizing filter 1mm thick.

The simulated criminal event

Outline of the event. The outline of the criminal event presented to the participants was as follows. No sound was recorded. The total length of the event was about one minute.

> A car pulled up before a pedestrian (female). The driver (male) got off the car with a map in his hand to ask her for directions. While she was giving directions on a map, leaving her bag on the ground, a passenger in the car (female) quietly came out of the car, stole something from the bag and sneaked back into the car. Then the driver bowed his thanks to the pedestrian and drove away. The pedestrian started walking again without noticing the theft.

Three contradictory points. In order to create conflict among eyewitnesses, two versions of the same basic event were prepared and videotaped. Only the following three points differed between the two versions: (a) the color of the car, a white car vs. a dark car; (b) the clothes of the driver, a white shirt vs. a parka with stripes; and (c) the direction of the pedestrian after the theft, walking up toward the screen vs. walking down away from the screen.

Results

The MORI technique worked perfectly judging from various data obtained from the experiment. First of all, no participants reported that they noticed the presentation trick according to the post-experiment interviews. The fact that the participants did not suspect any shenanigans was also inferred from the discussion sessions; no groups ended up without reaching an agreement even on the three conflicting points. If they had thought they had observed different things, they would not have reached agreement on initially divisive points. The week-later reports also showed some evidence of their belief that they had all watched the same thing. Once they reached an agreement, those who had changed their minds tended to report the distorted memory a week later again, with or without being aware of it. Even those who changed their minds after discussion rated high on confidence in their week-later reports. These evidential behaviors were observed across the board. The results were replicated in subsequent experiments (Hirokawa, Matsuno, Mori, & Ukita, 2003; Mori, Kanematsu, Mori, Yamaguchi, Shizuyama, & Fujisawa, 1999; Mori & Mori, 2003) with varying eyewitness groupings and presentation conditions.

EVALUATION OF THE MORI TECHNIQUE

Several experiments and a demonstration have been conducted using the MORI technique as summarized in Table 1. The MORI technique was found to be successful in achieving its goals throughout these applications, judging from the criterion of the trick not being noticed by participants. The results of those experiments are not the focus of this paper and thus are not described in detail. The technical aspects of those experiments that are more relevant to the purpose of this paper are discussed below. Results from these experiments and demonstration showed the applicability of the MORI technique in research involving various types of participants, apparatus, and experimenters.

The MORI technique has been used in experiments with participants of various ages and

Table 1
Summary of experiments using the MORI technique

Exp.	Participants	Group size	Equipment		Location	Publications
			Projector type	Video contents		
(a)	60 undergraduates	2	PD-V7(LCD)	Hi8/analog	Mori lab.	Kanematsu et al (1996/2003)
(b)	78 undergraduates	3	PD-V7(LCD)	Hi8/analog	Mori lab.	Mori & Mori (2003)
(c)	60 undergraduates	4	PD-V7(LCD)	Hi8/analog	Mori lab.	Mori & Mori (2003)
(d)	60 undergraduates	2	VIP4000(LCD)	Hi8/analog	Mori lab.	Mori et al (1999)
(e)	48 undergraduates	2	PD-V7(LCD)	Hi8/analog	Ukita lab.	Hirokawa et al (2003)
(f)	53 undergraduates	2 or 3	D-1200X(DLP)	digital animation	Mori lab.	In progress
(g)	30 mothers/children	2	PD-V7(LCD)	Hi8/analog	Mori lab.	Mori (2003)
(h)	16 high-school students	8	VIP4000(LCD)	Hi8/analog	Mori lab.	Demonstration

both sexes. A total of 359 undergraduates participated as eyewitnesses in groups of various sizes, in pairs (a, d, e, and f), in triads (b and f), or in foursomes (c), and various sex combinations (e). In an ongoing experiment (g), 15 mothers and their children aged from 6 to 12 years old participated as mother-child eyewitness pairs. In addition, 16 high school students from 12 to 17 years old attended demonstration sessions of this method (h) during a two-day summer seminar in introductory psychology at Shinshu University in 2001. They observed the video event in groups of 8. None of them noticed the trick. These results showed the wider applicability of the MORI technique across various ages and genders.

This technique was also shown to be effective regardless of the projector type or video contents. In the demonstration (h) and an experiment (d), a pair of much brighter LCD projectors (Yokogawa VIP4000) was used to examine the effectiveness of the MORI technique under much clearer viewing conditions and with a wider screen. The brighter the image, the more the chance the duality could be detected. However, it was found that even with the brighter projectors the MORI technique was effective. The simulated criminal event was made into an animated cartoon and projected by a pair of DLP projectors (Yokogawa D-1200X) in another experiment (f) to test the MORI technique's reliability with different presentation equipment and materials. The results confirmed that the MORI technique can be used with brighter projectors and various visual stimuli.

Furthermore, the MORI technique can be easily employed in any laboratory setting. Hirokawa and her colleagues (Hirokawa, et al., 2003) conducted an experiment (e) in another university using the same material as Kanematsu et al. (1996/2003) and found that female pairs remembered better than male pairs or mixed pairs. Participants in this experiment also did not detect the presentation trick. This demonstrated the general applicability of this technique regardless of the location or researcher.

CONCLUSION

This article presents a new technique for presenting two different visual stimuli simultaneously to two groups of viewers without them noticing the duality. The technique described is especially suitable for research requiring the creation of conflict among viewers. It is also advantageous in that this technique is easy to use for experiments with child participants. The results from several experiments conducted by the present author and others provided evidence of the effectiveness of the MORI technique with various projectors, different video materials, and viewers in different group sizes and of differing ages. It can be applied to a variety of psychological experiments in addition to the examples reported. It is hoped that the MORI technique will expand the opportunities for reliable psychological research.

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