

# A HYBRIDIZATION OF SIMULTANEOUS AND SEQUENTIAL LINEUPS REVEALS DIAGNOSTIC FEATURES OF BOTH TRADITIONAL PROCEDURES

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This study investigated a hybridization of simultaneous and sequential procedures to facilitate eyewitness identifications. The slideshow procedure presented photos to participants in a cycling loop, allowing them to view photos multiple times, but always one-at-a-time. We hypothesized allowing witnesses to view all photos without directly comparing them would increase correct identifications and correct non-identifications. Simultaneous presentation led to the most correct identifications, while sequential presentation led to the most correct non-identifications. The hybridization reduced both types of correct response and failed to support our hypothesis. The hybridization appears to promote guessing rather than conservative responding. Receiver operating characteristic (ROC) analysis revealed simultaneous advantage when making identifications, but sequential advantage when making non-identifications. We conclude that performing ROC analysis of both identifications and non-identifications may reveal the same interaction noted between perpetrator presence and lineup modality when analyzing identification decisions.

*Keywords:* eyewitness identification, simultaneous vs. sequential, ROC analysis, lineup hybridization, probative value

Empirical studies comparing the relative performance of simultaneous and sequential photo arrays in facilitating the eyewitness identification of criminal perpetrators are commonplace. Early studies (Lindsay & Wells, 1980; Steblay, Dysert, Fulero, & Lindsay, 2003) suggested that sequential administration reduced the likelihood of false identifications without posing a statistically significant threat to correct identifications, a phenomenon regarded as sequential superiority (see Wells, Memon, & Penrod, 2006 for a thorough

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review). Simultaneous administration was thought to increase the likelihood of a relative or comparative judgment, in which witnesses identified the closest match rather than truly recognizing who they remember as the culprit. Sequential administration forces the witness to make an identification based solely on their recognition of the person pictured.

Despite challenges to the statistical power of sequential superiority (Stebly, Dysart, & Wells, 2011), the effect sufficiently became accepted, and many police departments began to change their policies. In the early part of the century, real-world identifications almost always were facilitated by simultaneous presentation of suspects, either via a six-pack photo array or via live presentations of suspects in a single room. While simultaneous administration is still common, sequential administration is becoming increasingly so.

This change in public policy as a result of empirical work is encouraging. However, recent evidence suggests that simultaneous photo arrays indeed may produce better discriminability than sequential ones (Carlson & Carlson, 2014; Clark, 2012; Wixted, Gronlund, & Mickes, 2014). These researchers analyze not only rates of correct and false identifications, but also rely on Receiver Operating Characteristic (ROC) analysis, which plots the proportion of target identifications against the number of false identifications at each confidence rating. When curves are drawn connecting these points, increased area under the curve suggests increased discriminability of the procedure used. Mickes, Flowe, and Wixted (2012) provided a detailed rationale for this perspective and also provided the first experimental evidence of what they termed a simultaneous superiority effect following ROC analysis. Many studies (Carlson & Carlson, 2014; Wixted et al., 2014, Gronlund et al., 2012) have reported similar effects, though the differences in discriminability as measured by *D* (an effect size measure comparing differences in partial area under the ROC curves) are not always statistically significant. These results have cast some doubt on the sequential superiority effect derived from diagnostic ratios based on rates of hits and false alarms.

However, other researchers (Wells, Smalarz, & Smith, 2015; Smith, Wells, Lindsay, & Penrod, 2016) have argued that ROC analysis is not an appropriate assessment of identification decisions because such analysis requires dichotomous decision outcomes. ROC analysis regards identification decisions as dichotomous by focusing only on perpetrator selections in perpetrator-present (PP) conditions, and selections of a designated foil in perpetrator-absent (PA) conditions. Both identifications of other foils in the lineup and non-identifications are disregarded by the analysis. The resulting ROC plots cannot measure fully the discriminability of lineup procedures, because foil identifications and non-identifications provide a great deal of probative value (Wells et al., 2015).

The debate regarding which methods best evaluate identification decisions has been vigorous. Lampinen (2016) recently published new criticisms of the ROC technique, and Rotello and Chen (2016) followed with an in-depth analysis of the debate and their own defense of ROC procedures. While the discussion regarding these procedures is ongoing, two conclusions seem inevitable. First, it likely cannot be argued that either simultaneous or sequential procedures are always superior. To that end, different procedures warrant continued exploration and that was our primary aim in this study. Second, a probative-

value framework and a ROC-discriminability framework both can provide important information, though both have limitations in how they organize and regard the data. Below, we provide both types of analysis of our data and discuss what our findings might suggest about both approaches.

### ***The Present Study***

The present study proposed a novel procedure for facilitating eyewitness identifications. The new procedure allows witnesses to view a continually looping slideshow of six photographs of suspects. Our participants could view the loop for as long as they wanted before making a single identification decision, as in a simultaneous procedure. However, they never had the opportunity to view more than one photograph at a time, as in a sequential procedure. Such a hybridization should provide the same information as a simultaneous procedure while eliminating the possibility for direct comparison and should, in theory, produce the following outcomes. First, the procedure should preserve the opportunity to make correct identifications in PP conditions, since all the photos can be viewed as often as the witness would like. Second, the procedure should discourage comparative, relative judgments by never making all the photos available concurrently and, therefore, should enable correct non-identifications in PA conditions. Therefore, the procedure concurrently should increase hits and reduce false alarms arising from relativistic judgments.

Making predictions about the ROC analysis of the hybridization was more difficult. The procedure should increase the ability to discriminate between the suspect and foils, which should improve the ability to make both correct identifications and correct non-identifications. However, how can ROC analysis fully test this prediction if it only evaluates identifications? We posit that conducting ROC analysis of non-identifications by plotting correct non-identifications in PA conditions against incorrect non-identifications in PP conditions more thoroughly would measure the discriminability of an identification procedure. Our review of the literature has found no other study that has attempted this, the rationale being that non-identifications are not actionable decisions judicially and thus do not warrant consideration (Mickes et al., 2012; Carlson & Carlson, 2014). Theoretically, the plots of each lineup procedure should show comparable discriminability for both identifications and non-identifications, with the slideshow hybridization providing the best discriminability by combining advantageous features of both simultaneous and sequential procedures. We test these predictions below.

## **METHODOLOGY**

### ***Participants***

Seven-hundred thirty-nine undergraduate students (178 males, 561 females; mean age 20.15; 63% Caucasian) from two southern universities completed the experiment in partial fulfillment of required study participation hours associated with a psychology course.

### ***Method***

Our study was conducted online using Qualtrics software. Many of the procedures for designing such a study were based on those described by Carlson and Carlson (2014), who also conducted a large-scale identification study online. The procedures used were piloted in-person with small samples at three southern universities. Data from these sessions are not included in the analyses.

Participants first watched a short video of a simulated crime. Two versions of the crime were filmed, each with the same actor committing the crime. In the first version, the perpetrator is walking down a hallway when he notices a discarded wallet on the ground. He bends to pick it up, and then walks directly past the camera, exiting the scene. In the second version, the perpetrator dumps trash in the same hallway—an act of littering—and then walks past the camera, exiting the scene in the same manner. Both videos are 30 seconds long and offer nearly identical exposures to the perpetrator. These variants in crime type were also a factor of interest, but they had no statistically reliable impact on identification performance and, as such, are not discussed further.

After viewing the video, participants completed two questionnaires as filler tasks to create a delay between viewing the crime and viewing a photo array. The first was the Balanced Inventory of Desirable Responding (Paulhus, 1991), a 40-question survey that asks participants to rate how frequently they engage in various behaviors. The second was a version of the Shipley IQ inventory (Zachary, 1986), a 40-question vocabulary test that asks participants to select the best synonym for a given word from four possibilities. The rate at which these tasks were completed depended upon the level of investment of each participant. Typically, these tasks take a total of 10 to 15 minutes when being completed by participants in the laboratory.

Following these two questionnaires, participants were asked to identify the perpetrator of the crime they had viewed at the beginning of the protocol. Three different lineup procedures were used to facilitate the identifications: Simultaneous, sequential, and slideshow. PP and PA versions of each photo array were produced, creating a total of six lineup conditions. The birth month of the participants was used to assign them to one of the six conditions.

**Simultaneous procedure.** The simultaneous photo arrays presented six possible suspects in two rows of three photos, numbered 1-6. Participants were given as long as they wanted to study the array before making a decision. They were given the option to either choose a suspect or indicate that the true perpetrator was not present.

**Sequential procedure.** The sequential photo arrays presented photographs one-at-a-time and required participants to make a yes or no decision before proceeding to the next photograph. If a participant positively identified one of the photographs, the array terminated and the remaining photos in the sequence were not viewed.

**Slideshow procedure.** In our hybrid procedure, participants were shown one photograph at a time in a continuous loop. They were allowed to view all the photographs

before making a decision (though not required to view the entire loop) and were allowed to watch the loop cycle through as many times as they wanted before making a decision. Each photograph was on the screen for five seconds before cycling forward, and participants were unable to interrupt the loop in its progression. Additionally, photographs were not labelled with numbers, but instead with shapes such as square or triangle. Our aim in using shapes instead of numbers was to eliminate the perception that the sequence had an established beginning and end. The loop also was designed to begin with a random photograph, so that there truly was not a consistent beginning and end photograph in the sequence throughout the study. When participants were ready to make an identification, they were asked to keep in mind the shape denoting the photograph they were choosing, then click forward to the next screen to make the identification, or indicate that the perpetrator was not present in the loop.

In all lineup conditions, participants were cautioned that the true perpetrator of the crime might not be present. After making a decision, participants were asked to rate their confidence in their identification on a 0% to 100% scale, with 10% intervals. The confidence rating concluded the study.

**ROC Analysis.** The ROC procedure for eyewitness identifications described by Mickes et al. (2012) and employed by several others plots target identifications in PP conditions against false alarms in PA conditions. A designated foil, often referred to as the innocent suspect, is identified in the PA array as the foil most likely to be chosen and is subsequently used as the plotted false alarm for the analyses. Identifications of other foils in the array are not considered. The left-most point on the resulting curves plots the proportion of hits against the proportion of innocent suspect false alarms at the highest confidence rating. The next point to the right adds responses made at the next highest confidence rating, until the right-most point finally includes responses made at all confidence levels.

In a pilot study to determine an innocent suspect for our ROC analysis of identifications, we asked 36 participants to watch one of the crime videos, then immediately view the simultaneous PA photo array, and make a forced identification. The suspect chosen most by this group became our innocent suspect. While the innocent suspect was chosen by a majority of participants (39%), another foil was chosen by 25% of participants, and each of the six photographs was chosen by at least one person. This suggests that our foils all had a high level of relative similarity to the perpetrator and were capable of effectively siphoning incorrect responses across the photo array. Wells et al. (2015) argue that the ability of a fair lineup with similar foils to siphon incorrect responses away from the target helps to protect an innocent suspect from falsely being identified. Additional pilot trials revealed that participants immediately given the opportunity to view the PP photo array correctly identified the perpetrator 86% of the time. We feel that our crime videos and lineups provided fair opportunities to view and identify the perpetrator, while also providing foils similar enough in appearance to the perpetrator to successfully mimic real-world photo arrays by siphoning incorrect identifications.

ROC analysis of non-identifications was less complicated. Correct non-identifications in PA conditions were plotted along the Y axis, while incorrect non-identifications in PP conditions were plotted along the X axis. Like the identification curves, these plotted the proportion of correct and incorrect decisions as increasingly less-confident responses were included.

## RESULTS

To facilitate comparisons with prior findings, we report several different outcomes. First, following the probative value framework described by Wells et al. (2006), we report rates of correct decisions, non-identifications, and foil identifications (which included identifications of our designated innocent suspect). These are reported as proportions of total responses in Table 1. We also analyze the decisions using ROC analyses, following the work of Mickes et al. (2012). We expand on these procedures by including ROC analyses of non-identifications in addition to identifications. The resulting ROC curves are found in Figures 1 and 2. Our ANOVA tables are included as Appendix A.

Table 1. Proportion of Responses in the Lineup Conditions

Condition	Correct Decision	Non- identification	Foil Identification
Perpetrator Present			
Simultaneous	0.62(.04)	0.09(.03)	0.29(.04)
Sequential	0.45(.05)	0.20(.05)	0.35(.05)
Slideshow	0.34(.04)	0.14(.03)	0.52(.03)
Perpetrator Absent			
Simultaneous	0.19(.03)	0.19(.03)	0.62(.03)
Sequential	0.34(.05)	0.34(.05)	0.66(.04)
Slideshow	0.11(.03)	0.11(.03)	0.89(.03)
Overall			
Simultaneous	0.41(.03)	0.13(.02)	0.53(.03)
Sequential	0.40(.04)	0.28(.03)	0.49(.04)
Slideshow	0.23(.03)	0.12(.02)	0.71(.03)

*Note:* Correct decisions are perpetrator identifications or correct non-identifications. Foil identifications are non-target identifications, including innocent suspect identifications. Standard error reported in parentheses.

Overall, correct decisions (which include target identifications in PP conditions and non-identifications in PA conditions) occurred more frequently following traditional procedures., although those conditions did not differ from each other,  $F(2, 733) = 14.54$ ,  $p < .001$ ,  $SEM = 1.7\%$ . However, perpetrator presence and lineup condition interacted,  $F(2, 733) = 7.33$ ,  $p = .001$ ,  $SEM = 2.1\%$ , as correct identifications occurred more frequently

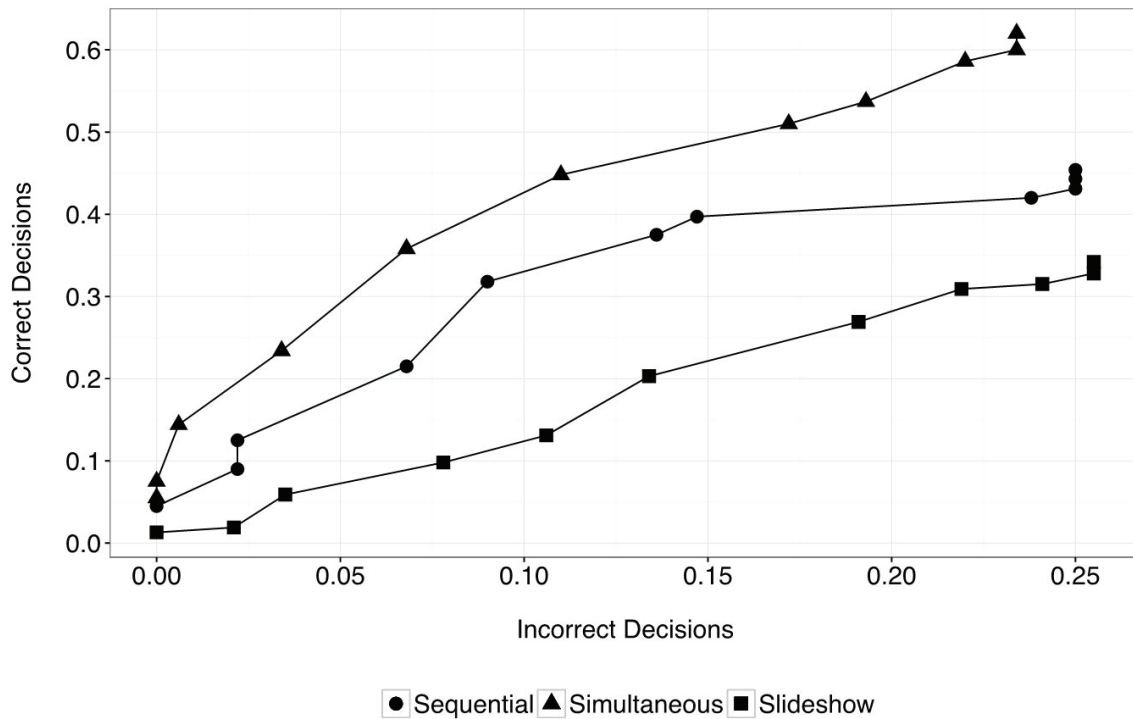


following the simultaneous procedures, but correct non-identifications occurred more frequently following the sequential procedure. These results support the conclusions of previous meta-analyses (Wells et al., 2006; Steblay et al., 2011) that simultaneous and sequential procedures provide comparable probative value, while also strongly refuting our hypothesis that the slideshow procedure should optimize probative value.

To the contrary, the hybridization maximized foil identifications, which occurred significantly more often following slideshow administration than following both simultaneous and sequential procedures,  $F(2, 736) = 13.83, p < .001, SEM = 1.8\%$ . Finally, the sequential procedure produced more non-identifications than the simultaneous or slideshow procedures, which did not differ from one another,  $F(2, 736) = 10.76, p < .001, SEM = 1.4\%$ .

These results suggest that our rationale for hybridization focused on the wrong characteristics of the simultaneous and sequential procedures. Rather than increasing correct identifications, the slideshow procedure instead reduced correct non-identifications to the level noted following the simultaneous procedure. Concurrently, the slideshow procedure led to a very high overall rate of foil identifications (71% of responses). The hybridization appears to promote identifications without providing ample opportunity to determine the suspect through direct comparison. In short, removing the opportunity for comparison appears to promote guessing, not more conservative responding.

ROC curves (see Figure 1) plotting innocent suspect identifications in PA conditions against target identifications in PP conditions replicated previous findings (Carlson & Carlson, 2014; Gronlund, Wixted & Mickes, 2014) by indicating that the simultaneous procedure allowed for better discriminability than the sequential procedure. The slideshow procedure again failed to support our hypothesis, this time by producing the lowest discriminability of the three conditions, rather than the highest. This is consistent with the low accuracy rates and high foil identification rates discussed above.



*Figure 1.* Receiver operating characteristic analyses (ROC) plotting innocent suspect identifications in perpetrator-absent conditions (Incorrect Decisions) against target identifications in perpetrator-present conditions (Correct Decisions). The left-most point on each curve reflects decisions made at the highest confidence level. Each point to the right includes decisions made at the next-highest confidence level, until the final point includes all decisions at all confidence levels. Increased partial area under the curve (pAUC) suggests better discriminability.

Despite the prominent differences in the curves, the results were not statistically reliable (see Table 2). The statistical significance of differences between ROC curves is measured by comparing the differences in partial areas under the curve (pAUC), with higher pAUCs indicating better discriminability. Following the example of Mickes et al. (2012) and others, we computed the effect size measure  $D$  to compare these differences.  $D$  is calculated as  $(\text{pAUC1} - \text{pAUC2})/S$ , where  $S$  is the standard deviation of differences in the pAUCs resulting from 2,000 bootstrapped simulations of the curves. These inferential analyses were conducted using the pROC package (Robin et al., 2011) in R (R Core Team, 2016). By default, pROC uses 2,000 bootstrap permutations for calculating  $S$ . We also calculated  $D$  after using 10,000 permutations to produce this error estimate, and the results were unaltered.



Table 2. Results of Inferential Analysis of pAUC Pairs for Identifications

Comparison	D	<i>p</i>
Simultaneous vs. Sequential	0.624	.532
Simultaneous vs. Slideshow	1.48	.139
Sequential vs. Slideshow	0.839	.401

*Note.* All comparisons based on pAUCs calculated with sensitivity = .88. Alpha = .05 for planned comparisons.

We consider our non-reliable differences as replications of previous findings because many of the studies (Mickes et al., 2012; Carlson & Carlson, 2014; Gronlund et al., 2012) report both significant and non-significant differences in D as support for their conclusions. Statistical significance appears to only emerge with very large sample sizes or when target and innocent suspect identifications constitute a large proportion of responses. The rate of foil selections impacts the number of decisions included in the ROC analysis. If other foils are selected frequently, fewer decisions can be analyzed by the procedure, which leads to a reduction in the reliability of the resulting pAUCs. Wells et al. (2015) discussed the importance of foil selection, or filler siphoning, in their criticism of the use of ROC procedures for analyzing eyewitness decisions. While Rotello and Chen (2016) argue that filler siphoning is irrelevant, it does impact the reliability of theoretical testing using ROC analysis by affecting the number of cases included in the analyses.

Finally, the ROC curves of non-identifications (see Figure 2) plotted incorrect non-identifications in PP conditions against correct non-identifications in PA conditions. Like the ROC curves for identifications, these plots disregarded identifications of foils. The resulting curves also failed to support our hypothesis by demonstrating poor discriminability following the slideshow procedure, although the hybridization did provide better discriminability than the simultaneous procedure when making non-identifications (see Table 3). The slideshow curves describing both identifications and non-identifications hovered around the central diagonal, suggesting that confidence ratings following this procedure provided no useful prediction of accuracy. These plots, along with the low rate of correct decisions, suggest that the slideshow hybridization is inferior to both traditional lineup procedures.

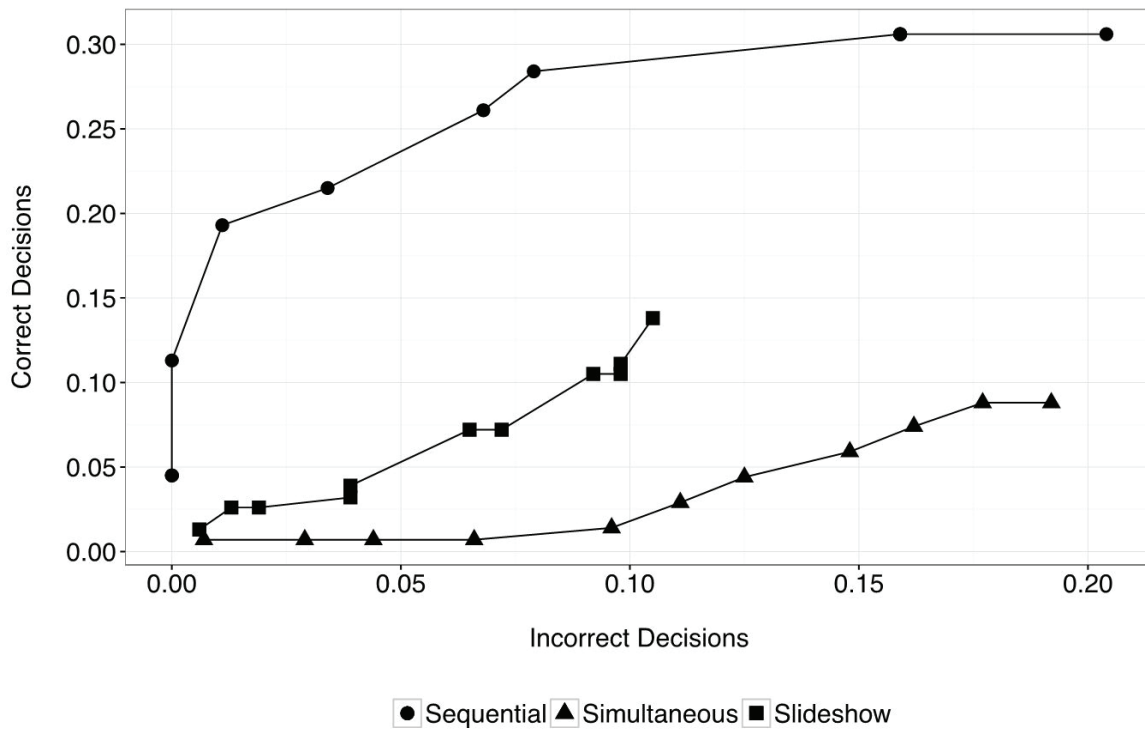


Figure 2. Receiver operating characteristic analyses (ROC) plotting incorrect non-identifications in perpetrator-absent conditions against correct non-identifications in perpetrator-present conditions. The left-most point on each curve reflects decisions made at the highest confidence level. Each point to the right includes decisions made at the next-highest confidence level, until the final point includes all decisions at all confidence levels. Increased partial area under the curve (pAUC) suggests better discriminability.

Table 3. Results of Inferential Analysis of pAUC Pairs for Non-Identifications

Comparison	D	p
Simultaneous vs. Sequential	-2.49	.013
Simultaneous vs. Slideshow	-1.64	.101
Sequential vs. Slideshow	1.12	.263

Note. Negative D values indicate an advantage for the condition on the right. All comparisons based on pAUCs calculated with sensitivity = .88. Alpha = .05 for planned comparisons.

When plotting non-identifications, the positions of the simultaneous and sequential curves unexpectedly flipped relative to the identification curves. In fact, the sequential advantage relative to simultaneous when making non-identifications produced the only statistically reliable difference in discriminability noted in the study. This makes sense, given the interaction between lineup modality and perpetrator presence described above, and the large separation between the curves in Figure 2. Collectively, the curves suggest that

the simultaneous procedure produces the highest discriminability when an identification is the correct response, while the sequential procedure produces the highest discriminability when a non-identification is the correct response.

## DISCUSSION

This study used traditional accuracy measures and the recent technique of ROC analysis to analyze a hybridization of simultaneous and sequential lineup procedures. This slideshow hybridization, which allowed witnesses to see all photographs in a continuous loop but did not afford the opportunity for direct comparison, was hypothesized to increase the accuracy of both positive and negative identification decisions by combining perceived benefits of the simultaneous and sequential procedures. Our results failed to support this hypothesis. Instead of reducing the likelihood of false identifications in PA conditions, removing the opportunity for direct comparison reduced the likelihood of correct identifications in PP conditions. Likewise, instead of increasing the likelihood of non-identifications in PA conditions, the slideshow procedure reduced the likelihood of non-identifications to the same level seen following simultaneous procedures.

ROC analysis of both identifications and non-identifications also revealed that the slideshow hybridization provided virtually no discriminability. Both curves fell along the central diagonal of the ROC plots, suggesting that confidence estimates following the slideshow procedure provided no useful prediction of the likely accuracy of responses. An unexpected result was the reversal of the simultaneous and sequential curves when plotting non-identifications instead of identifications. Sequential administration allowed far better discriminability when making non-identifications than did simultaneous or slideshow procedures.

Taken together, these results suggest several things. First, the slideshow hybridization was ineffective and should not be considered as an alternative to simultaneous or sequential procedures. While this is a practical failure, the nature of the failure sheds some light on our theoretical assumptions about the characteristics of photo lineups. The simultaneous and slideshow procedures were most alike in their relative inability to produce non-identifications. These two procedures share two characteristics: They allow the witnesses to see all photos before making a decision, and they require a single identification decision. The requirement to make a single decision appears to have a more prominent impact on non-identification rates than the opportunity to see all photographs does on correct identification rates. Allowing witnesses to see all the photographs does little to reduce the likelihood of foil identifications when a single decision is required. This finding replicates those of another study of lineup hybridization (Dillon, McAllister & Vernon, 2009), which varied the size of arrays, presenting six photographs either simultaneously, sequentially, or in groups of two or three. All of the non-simultaneous arrays were better at producing non-identifications, though simultaneous presentation still excelled at producing correct identifications.

Second, our study supports previous findings (Gronlund et al., 2014) that ROC analysis of identifications reveals better discriminability following simultaneous administration, regardless of the relative rates of correct and incorrect identifications. However, our study also calls into question the conclusion of Gronlund and colleagues (2014) that simultaneous procedures always provide increased discriminability. Better discriminability should increase the likelihood of correct decisions in both PP and PA situations, but our data cannot support this conclusion regarding simultaneous lineups. Both the probative value framework and the ROC framework suggest sequential administration to be a superior procedure when the perpetrator is not present.

Third, we feel that the best explanation of our accuracy rates and our two sets of ROC curves is the interaction that exists between lineup modality and perpetrator presence. Our study suggests that the source of the interaction is not the manner in which witnesses view photographs, but rather the manner in which they make identification decisions. Though it is an inconvenient conclusion for the judicial system, we feel that the presence or absence of the perpetrator in the array is the best predictor of which traditional procedure will produce the best outcome, whether measured by probative value diagnostic ratios or ROC discriminability. To that end, we encourage other researchers to continue exploring novel procedures for facilitating identifications. Rotello and Chen (2016) assert that a sequential procedure that does not require a single identification decision should increase discriminability as measured by ROC analysis, and we assert that such a procedure should also concurrently increase rates of correct identifications and correct non-identifications.

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Date Received: 11/2016

Date Accepted: 03/2017

Suggested citation: Terrell, J. T., Baggett, A. R., Dasse, M. N., & Malavanti, K. F. (2017). A hybridization of simultaneous and sequential lineups reveals diagnostic features of both traditional procedures [Electronic Version]. *Applied Psychology in Criminal Justice, 13*(1), 96-109.

## APPENDIX A

ANOVA table for Accurate Decisions

Source	<i>Sum of Squares</i>	<i>df</i>	<i>F</i>	<i>p</i>
<b>Lineup Condition</b>	5.647	2	14.542	.000
<b>Perpetrator Condition</b>	11.565	1	59.561	.000
<b>Lineup*Perpetrator</b>	2.845	2	7.327	.001
<b>Error</b>	142.324	733		
<b>Total</b>	250.000	739		

ANOVA table for Foil Identifications

Source	<i>Sum of Squares</i>	<i>df</i>	<i>F</i>	<i>p</i>
<b>Lineup Condition</b>	6.466	2	13.825	.000
<b>Error</b>	172.118	736		
<b>Total</b>	437.000	739		

ANOVA table for Non-Identifications

Source	<i>Sum of Squares</i>	<i>df</i>	<i>F</i>	<i>p</i>
<b>Lineup Condition</b>	2.836	2	1.418	.000
<b>Error</b>	97.002	736		
<b>Total</b>	119.000	739		

*Note.* Lineup Condition includes simultaneous, sequential, and slideshow procedures. Perpetrator Condition includes perpetrator-present and perpetrator-absent procedures. Proportions and standard error of means for these variables are reported in Table 1.