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Impact of Colour Sequencing on Print Quality in Process Colour Printing

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ABSTRACT

Colour printing is the process whereby illustrative materials are reproduced in colour on printed pages. This research has been conducted in order to compartmentalize and possibly aggregate the various sequences which printers use in producing their works; this is because a survey of most Nigerian print houses shows that these printers use different schemes in their production processes. The four colour process is used to produce a complete range of colours; the materials to be reproduced are separated into three basic colours plus black which is used for density and image contrast; these colours are Cyan, Magenta and Yellow, plus black which is regarded as the key colour. CMYK refers to the primary colours of pigment: Cyan, Magenta, Yellow and Black. These are the colours used in the printing press in "Four-colour process printing". The objective of this study is to find out which of these sequencing produces the best print, their pros and cons and the best possible ways to navigate these various schemes. In this paper, the writer takes a look into what printers and machine minders thinks is the proper sequence of printing these colours and the processes from pre-press to finishing. The method used in this research is mixed, with survey, descriptive and literature review and so at the end it was concluded that various printers have their respective ways of arranging colours to suit their expertise and that irrespective of the sequencing type used, the dexterity and astuteness of machine minders matters a lot.

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Introduction

This paper is academic in outlook but professional in content, therefore the writer dwelt on the practicality and techniques of process colour printing as it relates to paperwork and other media. Printing in the words of Peddie (1914) is an old professional practice that started in the ancient times especially in the Chinese dynasties whereas, printing, according to Dennis and Jenkins (1990) is a process for reproduction of texts and images and other illustrations using a master form or template from one medium to another. Printing is actually an art and science of transferring an impression from one medium onto another. Baldwin and Roberts (2006) avers that the business of printing is as old as the press and printing machine itself; the history of printing dates back to the introduction of the printing machine by Johannes Gutenberg in the year 1440 in Mainz, Germany and by the year 1450, the printing machine was perfected and ready for commercial use.

The earliest known form of printing as applied to paper as observed by Knobbler (1980) was the woodblock that was practiced in China around 220AD and this process was used for cloth printing; from this period, later innovations in printing technology as noted by Philip (2012) included the movable type invented by Bi Sheng at about 1040 AD, thereafter the printing press was invented by the German, Johannes Gutenberg at about 1450. This latest development in printing technology played a pivotal role in the development of the Renaissance and from here, printing spread to other parts of the world.

Every printer and clients of printers desires to see a cutting-edge finished printed material; this desire does not just come by happen stance; there are certain principles to be considered when planning a finished print job. This paper will start by looking at the various stages a particular print job undergoes before a final product is achieved. Depending on the machine minder or operator, different printers chose their preferred colour sequence. In the words of Burch and Gamble (1983), to some, the preferred print order for CMYK printing is as follows:

1.Yellow

2.Magenta

3.Cyan

4.Black

Burch and Gamble (1983) stressed that the above sequence is preferred if printing with a white under base; otherwise, there would be no need to flash and juggle between colours. Generally, the four-colour process uses Cyan, Magenta, Yellow and Black inks. When applied in successive layers, these four ink colours create a full process colour image. This four-colour process is the most widely used method for printing full colour images.

Irrespective of the method of printing, be it serigraphy, or digital printing, this sequence stands out in achieving the desired full colour print work. In this essay, the writer dwelt on the full colour process printing; process colour reproduction according to Kapplan (2000) can be created by producing an optical illusion for the observer and so by printing three or four colours over each other; supporting this assertion, Lester (1995) noted that the viewer sees what appears to be a continuous tone colour print and in actual fact whereas what is seen are three or four colours which have been printed over each other in order of preference.

Figure 1, clearly illustrates how a combination of certain colours can produce other colours. In practical terms, magenta, cyan and yellow are used to produce process colour prints while black is often used in combination with these three colours to add more details to the print.

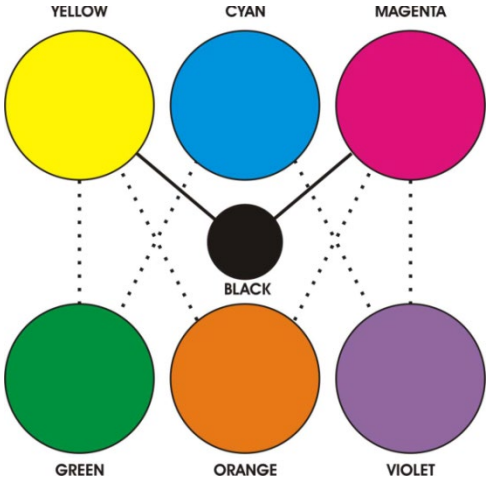

Figure 1. Possibility of producing other colours from three colours (Source: F. Osaigbovo, 2024)

Hyatt-Major (2012) is of the opinion that process colour printing is much more complicated than black-and-white halftone print; more often than not, he stressed that it requires equipment and materials usually not found in school studios or small graphic arts laboratories; therefore new printers are usually encouraged to attempt to make colour separations and should not become discouraged if the quality of the results does not meet the standards of commercial prints. Manufacturers offer several excellent publications which will permit one to study the colour separation procedure in much more detail.

Objects, according to Sturken and Cartwright (2001) most often appear to have colour because the human eye is sensitive to various wavelengths of light. It is believed to have the three primary light colours of Blue, Green and Red. When white light strikes an object, the object is capable of absorbing all of the light, reflect certain wavelengths and also absorb other wavelengths; if all the white is absorbed, the object appears black whereas when all of the wavelengths are reflected, the object appears to be white. In the same vein, those objects that absorb some of the light waves but

reflect others appear to have the colour of the combined wavelengths which are reflected. Giving credence to the assertion of Sturken and Cartwright (2001), Stephen and Balance (2001) submitted that when light passes through an object such as coloured glass windowpane, the same principle applies, meaning that certain rays of white light are permitted to pass through, but are not absorbed. The rays that do not pass through are absorbed by the material. A clear windowpane permits all of the white light to pass through while a yellow windowpane allows only yellow rays to pass through, absorbing all the rays of other colours. Blue, Green and Red are known as additive primary colours whereas when light from all the three are combined, they amount to white.

At this point, it is important to state that printing in whichever format is a subset of the wider subject of Graphics which has to do with communication of ideas to the society and is in line with the submission of Abu-Ridah (2020) that Graphic art eliminates exaggerated technical performances as he analyzes the important factors that influences artist's thinking in modern and contemporary art.

Statement of the Problem

The traditional CMYK (Cyan, Magenta, Yellow, and Black) colour sequence has been the standard in process printing for decades but its suitability for modern printing applications and substances still remain debatable. As printing technology continues to evolve and new materials, software and inks are developed, it is essential to re-assess the optimal colour sequencing strategy to achieve accurate colour reproduction, minimize ink usage and maximize print quality. This research aims to explore the impact of different colour sequencing approaches on process print outcomes and to identify potential opportunities for improvement.

Materials and Methods

This research identified the most commonly used colour sequencing methods in process colour printing; it analyzed the advantages and disadvantages of each sequencing method and results of experimental testing thereby highlighting the impact of different sequencing methods on print quality.

A mixed-method of investigation was employed in this research which included survey, interview with printers and machine minders to gather information on their sequencing practices and rationales, literature review of existing research on colour sequencing in process colour printing and direct observation and descriptive methods. Six print houses were randomly sampled; they included the University of Benin Printing Press (Benin City), Ma'azelli Print shop (Asaba), Mindex Press (Benin City), Feni 'O' Prints (Lagos), Clear Impressions Limited (Kano) and Planet Press, (Lagos) all in Nigeria. In these six print houses, their methods of printing and their machines were studied and this includes the Black-Cyan-Magenta-Yellow for Clear

Impressions Limited, and Planet Press, Cyan-yellow-Magenta-Black for Ma'azelli, Feni 'O' and Mindex Press, Yellow-Cyan-Magenta-Black for University of Benin Press.

The process of this research started from Kano, Northern Nigeria where Clear Impressions Limited is situated; this process includes direct observation and one-on-one interview with the machine minders. Adebayo (2021) of Clear Impressions Limited was studied; after a careful observation of his style and process, this writer asked what informed his sequence of colour print and his simple answer was that printing "Black" first gives a ready registration guide to follow in the case of printing the rest colours which are not as strong as "Black" and that in the event of inadvertent wrong registration; the mistakes might not prove as obvious and vivid. This was exactly the view of Mr. Johnson of Planet Press, Lagos.

In the case of Imafidon (2023) who manages the University of Benin Press, his idea of printing light colours first stems from the fact that "Black" which is the strongest colour, when printed last covers all wrong registration which may have occurred in previous colours. In the case of these two print houses Clear Impressions and Planet press employs digital colour separation system to obtain their transparencies used in lithographic plate making.

Colour Separation

In process colour print, colour separation is of paramount importance; colour separations are made from colour prints or transparencies of various colours which often come out black on the films. Light is reflected from colour prints as shown in Figure 2.

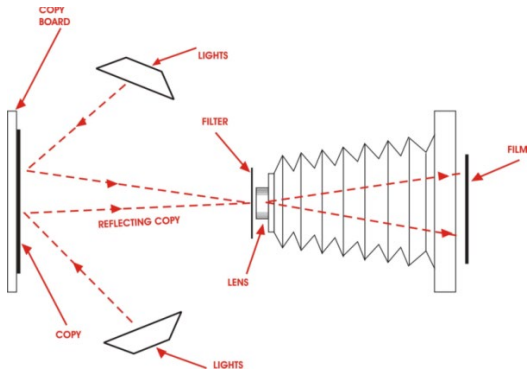

Figure 2. Light Directed at the Copy and reflected towards the film (Diagram: F. Osaigbovo).

Light is transmitted through the transparencies; however, the light source used to make colour separations must be almost the same as true white light. The process used in making colour separations is called the subtractive method whereby the separation negatives are produced by the use of filters which are the same as the additive primary colours of Red, Blue and Green. Here, the illustration of filters works just the same way as the window glasses described earlier. When the red filter is placed in front of the camera, it gives room to the red rays to pass through the lens

while preventing the blue and green rays from entering the camera. The separation negatives which are produced by the colour separation process are known as printers; there is a cyan, magenta and yellow printer for a three-colour process printing whereas four-colour process printing uses cyan, magenta, yellow and black printers.

The cyan printer (colour separation negative) is made by placing a red filter between the copy and the film; this will produce a negative that absorbs all of the red light from the copy meaning that where the copy has red colour, the corresponding part of the copy will be black on the negative whereas the part of the copy that has green and blue will remain clear on the negative thereby when the negative is printed, it should be printed in cyan. If a green filter is used, the magenta printer is produced; the green filter permits only green rays of light to get to the film therefore areas of the copy which has green in them passes through the filter while the red and blue rays are absorbed by the filter, so when this negative is developed, the black areas will correspond to the green areas of the copy and if a printing plate is made from this negative, everything will print except the green areas of the copy. This process has subtracted the green from the copy therefore the plate would print all areas which correspond to the red and blue areas of the copy. Finally, the yellow printer is made by using blue filter. The negative records the entire yellow colour on the copy whereas the red and blue colours do not enter the film so when the film for the yellow printer is developed, the areas of the copy that has green and red will not affect the film and these areas will appear clear.

Theoretically, these three printers described should be able to reproduce the same image as the copy but due to the fact that the inks used to print the separation may not be accurate, the gray and black areas may appear brownish, that is why most printers use a fourth printer which is the black to produce image which most precisely approximates the copy. Goldstein (1980) avers that there are several methods that can be used to make the black printer; one such method used by most professionals is the three filter method. The method requires that a piece of film which is the same type used in making the other three printers receive three separate exposures; one each, through each of the filters; These exposures may vary from 30 to 100 per cent of time used to produce the printer but must correspond to the proportion of colour on the copy, for instance, if a copy has red as the dominant colour, the exposures through the green and blue filters will be longer than the exposure through the red filter because the printer produced by using the red filter will not print any red colour. Since the black printer is intended to add details and contrast, the major portion of the original is red; the black should have a predominant impact on the printers that produce the red in the print.

Process colour printing starts with an original piece of copy which is the composite as shown on the bottom part of Figure 3. The copy can be transparency, painting, photograph or even drawing. Colour prints are reflection copy which means that light strikes the copy and bounces

back to the film whereas transparencies are transmission copies meaning that light passes through the copy. The light from the copy passes through the filters before reaching the film. This process of filtering produces the three or four different negatives is known as printers; the negatives are screened to produce halftone negatives which are required to produce the original.

The illustration above seems more like the manual or analog type of colour separation unlike the next stage of discussion which is the digital or automated colour separation system.

Figure 3. Progressive separation of colours Photograph (Source: F. Osaigbovo, 2024).

Result

One may ask what the outcome of the findings in this research was; like the writer opined earlier, that it is best to stick to the formula that works well or that best suits one's purpose. A critical look at the prints from these six print houses shows little or no noticeable differences as regards output in terms of sharpness, registration and accuracy apart from the fact that the machines used in the printing of these jobs also contribute to the quality or otherwise of the final output. With the foregoing, the writer concluded that whatever sequences that best suits ones purpose should be adhered to and perfected for better finality.

Discussion

A lot of printers and machine minders have come up with different colour sequencing types whereas most of these persons say they print according to the nature of the task which they undertake in the sense that if lighter colours are printed first, the machine may not need to be cleaned before a stronger colour is laid over it. The normal sequence of printing is as arranged in C-M-Y-K; that is cyan plate is to be printed first, followed by magenta, yellow and then black.

This discussion will finally zero down in two print houses namely Clear Impressions Limited and Planet press; reason is that these two print houses are the most modern and sophisticated of

the six advanced for this investigation. Johnson (2023) reiterated that in most cases, his machine minders starts from the lightest colour which is yellow and progress toward a stronger colour which is black; in which case, cyan and magenta comes before black, meaning that their formula is Y-C-M-K. Although the normal sequence which is also scientifically verified is the C-M-Y-K, the writer finds out that the machine minders at Clear Impressions Limited prints the black plate first. Asked why they print black which is supposed to be the last first, Omoluabi (2021) answered that it was easier for him to print black first so as to use the impression register the rest colours; after printing black, they follow it with magenta, cyan and lastly yellow making their sequence K-M-C-Y; whereas Johnson submitted that printing black last will enable it cover some errors that would have arisen from wrong registration.

There are some other sequence methods like K-Y-M-C which is the reverse of the C-M-Y-K; this sequence is commonly used in screen printing and flexographic printing whereas, in some specialized spot colour printing, sequence like R-Y-B (Red-Yellow-Blue) and also, sequence like R-G-B-C-M-Y-K (Red-Green-Blue-Cyan-Magenta-Yellow-Black) which is a combination of all schemes are used in some high-end digital printers. Also, the hexachrome combination Cyan-Magenta-Yellow-Black-Orange-Violet is used for expanded colour gamut.

These sequences may vary depending on the specific printing process, ink properties and desired colour output and so in most cases, printers chose the sequence that best suits their needs considering factors like colour accuracy, print quality and cost. Like was mentioned, different printers choose their preferred sequence for various reasons including the following:

a) C-M-Y-K: This is the most commonly used sequence and widely used in offset and digital printing and it's compatible with most printing machines. Cyan and Magenta inks provides good light-fastness.

b) C-M-Y-B: In this case, reversing black with blue may improve ink density and colour consistency and so some digital printers use this sequence to optimize their specific ink sets.

c) C-M-Y-K-O-G: Adding orange and green to the four proves colours would expand the colour gamut and improve colour accuracy, this sequence is used in most high-end digital printing like packaging and commercial printing.

d) K-Y-M-C: Starting with black creates a solid base before adding other colours; this is mostly used in screen printing and flexography where ink order affects dot gain.

e) R-Y-B: This sequence is used in spit colour printing where specific colours are required; Red, Yellow and Blue inks are often used for bright and vibrant colours.

f) RGBCMYK: Additive RGB and subtractive CMYK are combined for expanded colour gamut.

In all these, printers considers factors like ink properties (light-fastness and density), print process limitations (dot gain, ink spread), desired colour output (colour accuracy and vibrancy), equipment and technology capabilities, cost and ink usage considerations when choosing colour sequence because they aim to achieve the best possible print quality, colour accuracy and consistency for specific needs; and also, it is important to note that each sequence also has its own limitations and potential drawbacks depending on the specific printing application and requirements therefore, printers must carefully consider these factors when choosing a colour sequence to ensure the best possible print quality and colour accuracy for their specific needs. Over and above all these postulations, these sequences can also be applicable to other media like polyester fibers and fabrics as substitutes for natural fiber and cotton especially in sublimation printing. Nazari, Davodi Roknabadi and Darvishi (2019) postulates that sublimation printing is a method of converting images to printable images by which the device receives designs from computer files and printed in a transparent manner.

Much as there are advantages inherent in these various sequences, it is also important to note that there are also some disadvantages for instance Daly (2002) posited that some of the disadvantages could include but not limited to the following:

a) C-M-Y-K: Although it is the recommended sequence, this scheme has limited colour gamut and potential for colour inconsistency in the sense that if there are spot colours in the file to be printed, CMYK combination cannot give the appropriate colour.

b) C-M-Y-B: This combination might not be compatible with all colour printing equipment and result in limited colour accuracy.

c) C-M-Y-K-O-G: This scheme requires additional inks which in turn increase cost and may not be suitable for all printing applications.

d) K-Y-M-C: This scheme might lead to increase dot gain and might result in limited colour consistency.

e) Y-M-C-K: This scheme may lead to limited colour accuracy and may not be compatible with all equipment.

These disadvantages underscore the trade-offs most printers face when choosing a colour sequencing scheme; each scheme has its strengths and weaknesses and so printers must consider their specific needs and equipment when selecting a scheme.

Conclusion

Colour sequencing in process colour printing plays a crucial role in achieving high-quality prints with accurate colour reproduction. By understanding the principles of colour separation, screening and registration, printers can optimize their colour sequencing to minimize errors and

ensure consistent results. This writer feels that if each colour plates are properly registered and printed, no matter what sequence is employed, the final product will just as well be perfect, but digitally, the sequence remains CMYK. This is evident in some printing machines like the Direct Imaging machine, the large format printing machine and DeskJet and inkjet printers.

Author Contributions

The author has done the conceptualization of the article and writing of the original and subsequent drafts.

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Data available on request from the author.

Ethical considerations

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