Checklists in Audio Production

by

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Declaration

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Abstract

Checklists in Audio Production

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This thesis investigates the role and implementation of the checklist in audio production studios. The goal of this study is to limit frequent human error by compiling and testing a checklist to be used in these studios. Procedures and checklists implemented in the life-critical fields of medicine and aviation have been studied and used as a framework, in order to shape this checklist to be relevant to a wide variety of audio production studios.

Uittreksel

Kontrolelyste in Klankproduksie-ateljees

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Hierdie tesis ondersoek die rol en toepassings van die kontrolelys in klankateljees. Die doel van hierdie studie is om te ondersoek of die gebruik van kontrolelyste aangewend kan word om menslike foute te beperk, deur middel van die samestelling en toetsing van 'n kontrolelys vir gebruik in hierdie ateljees. Werkswyses en kontrolelyste wat tans in die lewenskritiese sektore van lugvaart en die mediese wetenskappe benut word, is bestudeer en as raamwerk benut om te verseker dat hierdie kontrolelys toepaslik sal wees vir 'n wye verskeidenheid klankproduksie-ateljees.

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No paper has been wasted in the writing of this thesis; photocopies have been eliminated with sources being scanned in. This work will also hopefully be digitally available.

Dedicated to

my family,
for all their help
and motivation.

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Introduction

Audio production forms an important part of modern culture. It has only been in existence for a brief period of time (more than a century). As an art form, audio production has various ways in which it can impact individual responses. It can deliver an exceptional array of different moods, feelings and social commentary.

Recording engineers deal with complex systems that have a large number of variables where human error often leads to sub-optimal results. Procedures established in the life-critical fields of medicine and aviation as well as fields where potential losses are very high, such as manufacturing, specifically the use of checklists, might successfully be applied to audio engineering practice.

A recording is the product of a chain of events starting from a sound source being picked up by microphones (Dower, 1937:6), amplified to line level (Potts & Bruns, 1988:420), converted into a digital format (Moskowitz, 1996:1), processed by software (Cookson *et al.*, 1995:3) to end up in various distribution formats and platforms (Hoskins, 1999:5). Equipment of various manufacturers are connected together in a complex system under the control of a recording engineer who's task it is to make sure that every component in the system does what it is expected to do (Hepworth-Sawyer, 2013:7). Systems do not always behave in a predictable fashion and problems such as electromagnetic interference (Nagasawa *et al.*, 1985:6), noise (Zhu *et al.*, 2000:24), distortion (Aanonsen *et al.*, 1984:751), synchronisation errors (Steendam & Moeneclaey, 1999:1510), jitter (Mollenauer *et al.*, 1992:1576), and data storage errors often arise (Heanue *et al.*, 1994:751), in some instances caused by an incorrect action of the recording engineer.

A checklist is a list of action items or criteria arranged in a systematic manner, to record the presence or absence of the individual items or procedures listed to ensure that all are considered or completed. Hales & Pronovost (2006:2) believe a checklist should include all the "critical project success factors" on which a project relies to achieve a desired outcome (Parfitt & Sanvido, 1993). Life-critical fields such as medicine and aviation as well as fields where potential losses are very high, such as manufacturing and Formula 1, rely on checklists to minimise human error (Hales & Pronovost, 2006:3).

The aim of this thesis is to explore the checklists utilised in these fields, and to what extent they can be used to compile a checklist to be used in audio production studios, and might successfully be applied to audio engineering practice. This thesis also makes use of primary and secondary data. Firstly, questionnaires are used in order to gather data regarding the use of the audio production checklist. The relevant literature is researched. Summaries are made of the most useful sources to illustrate their relevance towards the purpose of this thesis.

Greene & Caracelli (1997:10) explain that mixed-method studies require concrete operations at the technique level of research by which "qualitative" and "quantitative" techniques are used together and either remain distinct design components, or are explicitly integrated. While qualitative research typically involves purposeful sampling to improve understanding of a vast amount of information, Patton (1990:385) explains that quantitative research involves probability sampling to allow statistical interpretations to be made.

In order to have an accurate outcome, according to Bogdan (1998:73), it is important to use an accurate method of data collection. Sandelowski (2000:248) explains that the grounded theory may be created using a combination of qualitative and quantitative data collection techniques and sources. According to Caracelli & Greene (1993:197), qualitative and quantitative data sets can be linked, or transformed to create one data set, with qualitative data converted into quantitative data, or vice-versa. This conversion is called [1] "Quantitizing" (Tashakkori & Teddlie, 1998:126). The constructivist conducting grounded theory has various experiential and socially constructed realities (Sandelowski, 2000:252). For the constructivist, conclusions are created, shaped or invented from data (Huberman & Miles, 2002:332).

Another data collection method chosen is content analysis which permits the researcher to notice common themes relating to the literature, but also permits one to scrutinise certain aspects of the research from the different perspectives of the participants involved (Berg & Lune, 2004:53; Maree, 2007:101). Thus, the additional comments on the questionnaires can be examined in order to identify the most prevailing themes (Caracelli & Greene, 1993:197).

Phenomenology involves describing the essence of the phenomena by using eidetic analysis (Tesch, 1990:23). This involves conceptualizing what is unchangeable through all the material gathered from the questionnaires (Sandelowski, 2000:251). Phenomenologists declare that eidetic description provides knowledge that faithfully reflects lived experience (Charmaz & McMullen, 2011:91). Creswell (1998:377) created a data analysis process model that en-

[1] Quantitizing refers to a process by which qualitative data is treated with quantitative techniques in order to transform them into quantitative data (Tashakkori & Teddlie, 1998:126).

ables the researcher to progress from the raw data to the final report. It follows: organising the data into smaller systematic units; a perusal[2] stage which involves surveying the collected data several times so as to get a better understanding; classification, where the identified themes from the perusal are grouped into the applicable categories; and synthesis, which creates an interpretation of the findings for the reader.

When the participants agreed to be involved in the study, they were given the option to withdraw at any stage. They were given a description of the study and could accept or decline to participate in the research.

Information was given to the participants involved, based on the outlined criteria. Phenomenological study's data analysis involves identifying essential statements (Tesch, 1990:23) from the conducted questionnaires; dividing the main themes based on their meaning (Leedy & Ormrod, 2005:142). This outlines the different outlooks on specific issues and recognises recurring themes, creating an overall conclusion based on the interpretation of the data (Sandelowski, 2000:251; Berg & Lune, 2004:53).

The largest problem that surfaces in reference to the checklist is the limited availability of research materials. Therefore, other fields such as aviation, product manufacturing, medicine and Formula 1 racing are researched in order to grasp the knowledge of checklists. Much attention has been devoted to sound technology development in this thesis, in order to help the reader understand the background of audio production and what it entails. After extensive searching, a checklist is compiled in order to aid audio production studios in the audio production process. The next logical step would be to see if it would work. The checklist is sent to various studios throughout South Africa, along with a questionnaire through which the data analysis chapter is compiled. Following the analysis chapter, information gathered in the analysis is used in the conclusion. The conclusion offers final reflections on checklists used in audio production studios, providing new insights into the importance of such systems.

2 The perusal stage also helps to identify common themes (Creswell, 1998:377).

Chapter 1

Background

Due to the lack of published research on this topic, this chapter will highlight the main areas in which checklists are already used most consistently. Although audio production has distinguishing characteristics that set it apart, opportunities are available to learn from other industries (Kaissi, 2012:66). This chapter investigates how audio production can learn from other industries, focusing on aviation, product manufacturing, Formula 1 car racing and medicine. Kaissi (2012:66) explains that evidence suggests a number of innovative practices originate with these fields.

Experience with other fields offers lessons applicable to the design of checklists (Barach & Small, 2000:763) that can be created for audio production. The above mentioned fields have many similarities as each of the disciplines involve teams of specialists using expensive equipment to perform tasks in life-threatening situations (Singh, 2009:360). A deeper search will be taken into research to find out how the checklists were created. According to Haynes *et al.* (2009:498), implementation should be neither costly nor lengthy.

It is important to produce a strategy for the sound style of a recording. This strategy will be an outline of the desired sound style, pointing one in the right direction in the organisation and planning of the project (Hepworth-Sawyer, 2013:34). Aviation, aeronautics and product manufacturing have come to rely heavily on checklists to aid in reducing human error (Parasuraman & Riley, 1997:232).

1.1 Checklists

A checklist, as described by Hales & Pronovost (2006:1), is a tool for the improvement of performance. The levels of cognitive function are often compromised with increasing levels of stress and fatigue (Reason, 2000:394), and are often the norm in certain complex, high-intensity fields of work. Checklists have been proposed as a manner to improve information retention (LeBlanc *et al.*, 2014:9). According to **?**:1, a checklist is an organisational tool that outlines steps in criteria and simplifies concepts aiding in information recall.

An important tool in error management across all of these fields is therefore the checklist, explain Hales & Pronovost (2006:1); Reason (2000:393), a key instrument in reducing the risk of costly mistakes and improving overall outcomes. The checklist is a promising tool for both research and clinical practice (Bishop, 1998:887). Downs & Black (1998:1) believe it is possible to produce a checklist that provides and alerts reviewers to its particular methodological strengths and weaknesses, as well as documenting an evaluation trail that should be followed, say Hyman & Cram (2002:131). Vivekanantham *et al.* (2014:4) explain that checklists in other industries have been shown to reduce errors, though these industries have not completely eliminated them.

Checklists serve as objectives, in terms of regulation and of certain processes, memory recall, and providing a framework for evaluations or as a diagnostic tool (Hales & Pronovost, 2006:1). The checklist is also used to ensure that all procedures are followed rather than relying on human memory alone (Hart & Owen, 2005:247). Verdaasdonk *et al.* (2008:2238) believe that research should aim to implement checklists for different procedures and investigate their effects. Checklist problems are not confined to specific fields; Degani & Wiener (1993:2) note that they also prevail in other industries. Checklists are described by Salzwedel *et al.* (2013:1) as established methods that help to structure complex processes in other high-risk fields such as aviation.

1.2 Aviation

The parallels between audio production and aviation make the aviation field an ideal source (Singh, 2009:360) for researching an audio production checklist. Clark *et al.* (2007:1) note that in recent decades, the airline industry has established an enviable record of safety, due, in large part, to the extensive use of a uniform, checklist-based approach to the management of certain high risk situations. The major function of the checklist is to ensure that the crew will properly configure the aeroplane for flight, and maintain this level of quality throughout the flight, and in every flight (Degani & Wiener, 1990:7). Hales & Pronovost (2006:2) state that the high-risk environment, in which pilots and astronauts find themselves, has led these industries to adapt both paper and electronic checklists into tools to help decrease human error. They believe it is considered a mandatory part of practice; so much so, that the checklist becomes flight protocol, and completion of a checklist from memory is considered a protocol violation.

Commercial aviation is an inherently risky industry that has been made safer through adherence to checklists and protocols (Hart & Owen, 2005:246). Regular flight practices including preflight checks, cockpit checks, starting engine checks, landing, and shut-down checklists, include checks for ground operation emergencies, take-off emergencies, ejection procedures, landing emergencies, and fuel system failures to delineate a few (Hales & Pronovost, 2006:2). As checklists and flight simulators become more prevalent and sophisticated, the danger diminishes and values of safety and conscientiousness prevail in aviation (Gawande, 2010:9). Completion of the checklist becomes the protocol for troubleshooting or problem solving, providing a systematic approach to emergency situation recovery (Hales & Pronovost, 2006:2). The improper use of checklists has been cited by Palmer & Degani (1991:1) as a factor in recent aircraft incidents and accidents. According to Degani & Wiener (1993:4), the major function of the flight deck checklist is to ensure that the crew will properly configure the plane for any given segment of flight. Pilots complete checklists not only to monitor the status of their procedures and equipment, but also themselves, say Hales & Pronovost (2006:2) the Illness, Medication, Stress, Alcohol, Fatigue/Food, Emotion (IM SAFE) checklist allows pilots to go through a qualitative evaluation of their physical, mental, and emotional status before embarking on a flight. Differences in checklist design will result in significant differences in crew performance (Segal, 1994:40).

Singh (2009:360) tells of a checklist that Boeing developed in the 1930s which assisted pilots in carrying out routine procedures in a time where flying was fast becoming more complicated. He explains that the results reduced the number of plane crashes, thus minimizing costs and reducing death rates. Through aviation, Safdar (2012:601) explains that we learn to identify a problem, which helps to determine the basic issues involved. It is then easier to obtain necessary information, and therefore formulate a response.

1.3 Product Manufacturing

In product manufacturing, according to Hales & Pronovost (2006:3), checklists are integral in ensuring the proper operating procedures are followed and the standards of quality are upheld. They state that processes such as automobile or food manufacturing, the production of pharmaceuticals and medical devices are highly monitored. Thus governing bodies such as the Food and Drug Administration in the United States and the Therapeutic Products Directorate in Canada use multiple checklists at all stages of drug or device development, ranging from preclinical phases to post-marketing phase studies to the manufacturing process itself (Wimmer, 1999:686).

Suzaki (1987:12) says use of a checklist will help avoid overproduction, transportation waste, processing waste, inventory waste, product defects, and will ultimately save a lot of time. Rusinko (1999:66) explains that manufacturability guidelines are positively and significantly related to achievement of performance goals. Fuller & Ottman (2004:1236) designed a checklist (see figure 1.1) in order to reduce the demand for materials and energy for midstream product manufacturing; they explain that it would also result in fewer waste outputs that must be managed.

Polution prevention (P2)
Manufacturing process-specific:
(1) Changing product manufacturing processes
(2) Changing manufacturing inventory processes

Product specific:
(1) Reducing materials intensity
(2) Modifying materials mix
(3) Extending useful life
(4) Minimizing operating waste/energy consumption
(5) Reinventing the core benefit delivery system

Resource recovery R2
Product reuse:
(1) Reusable packaging systems (2) Re-manufacturing/reconditioning/repairing

Materials recycling:
(1) Modifying materials mix
(2) Designing for disassembling
(3) Designing for recycling process compatibility
(4) Adopting materials coding systems
(5) Specifying recycled source materials

Materials transformation:
(1) Designing for WTE conversion
(2) Designing for composting

Figure 1.1: A Sustainable Product Design Strategies Checklist (Fuller & Ottman, 2004:1236)

When introducing a new product, the companies need to check the sales volume expectations, market share expectations, gross profit and break-even volume expectations, cannibalization potential from other company product lines, what competitive counter-moves are anticipated, and the projected product life cycle (Ribbens, 2000:5). This has helped suppliers to have greater design responsibility and fewer communication problems (Sobek *et al.*, 1999:75). Erixon *et al.* (1996:4) explain that when a good modular design is combined with a detailed system plan, the concurrent development of processes, products and assembly system changes are a lot simpler. With respect to checklist design, for example, ordering, wording, and level of detail can impact compliance (Bolton & Bass, 2012:340). Therefore, it is crucial that these checklists be complete, clear, and easy to use (Burian, 2004:1). Frakes & Van Voorhis (2007:248) state that checklists are a frequently recommended strategy for minimizing human error in the medical industry.

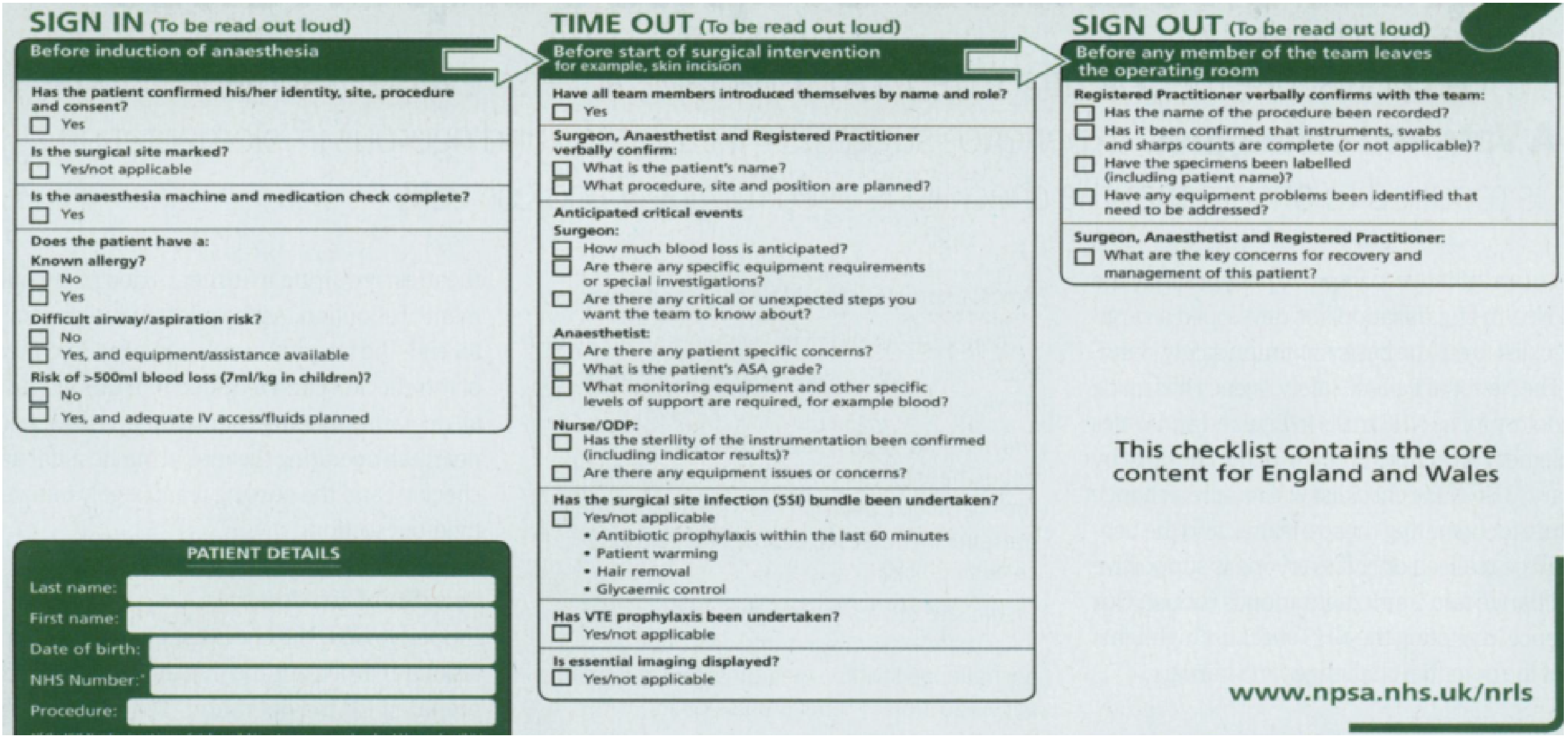
1.4 Medicine

Checklists have contributed to prevention of error under stressful conditions, maintenance of precision, focus, clarity, and memory recall in the medical field as well (Bogner, 1994:39). The checklist forces one to make sure that the required preparations are met with all of the case details before arriving in the Operating Room (OR) (Lingard *et al.*, 2005:344). The World Health Organisation (WHO) developed a surgical checklist to ensure basic minimum safety standards as part of an initiative to improve patient safety (Vats *et al.*, 2010:133). According to Conley *et al.* (2011:873), the WHO surgical safety checklist (see figure 1.2) has been adopted by more than 3,900 hospitals in 122 countries, representing more than 90 percent of the world's population. Furthermore, he says twenty-five countries are moving to adopt the checklist at a national level.

According to Hales & Pronovost (2006:3), the enforced standardization of processes, to which mandatory checklist completion can be applied, is a far more difficult task in medicine than aviation, given the unpredictability of human physiology. The degree of difficulty in every step is substantial (de Bakker *et al.*, 2008:126); then one must add the difficulties of orchestrating them in the right sequence, with nothing dropped, and leaving some room for improvisation (Gawande, 2010:3). In order to facilitate implementation and ensure its durability within the work-flow of the operating theatre, Vats *et al.* (2010:135) say the checklist has to be used effectively.

Kim *et al.* (2012:130) explain that a multidisciplinary paediatric team worked together to develop and implement a postoperative checklist and transfer protocol. The implementation of the checklist and transfer protocol was spaced over a subsequent 11-month period, involving 93 paediatric airway patients. The results of constant analysis showed no adverse events from miscommunication during the transfer of care (Kim *et al.*, 2012:130).

Checklists have already been demonstrated to be effective in high-intensity fields of medicine, such as trauma and anaesthesiology, and also in simpler matters such as a series of checks that occur before the delivery of anaesthesia, before any incision is made in the skin, and before the patient leaves the operating room (de Bakker *et al.*, 2008:126; Hales & Pronovost, 2006:3; Semel *et al.*, 2010:1593). According to Downs & Black (1998:2), checklists have also



SIGN IN (To be read out loud)

Before induction of anaesthesia

Has the patient confirmed his/her identity, site, procedure and consent?
☐ Yes

Is the surgical site marked?
☐ Yes/not applicable

Is the anaesthesia machine and medication check complete?
☐ Yes

Does the patient have a:

Known allergy?
☐ No
☐ Yes

Difficult airway/aspiration risk?
☐ No
☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
☐ No
☐ Yes, and adequate IV access/fluids planned

PATIENT DETAILS

Last name:
First name:
Date of birth:
NHS Number:*
Procedure:

TIME OUT (To be read out loud)

Before start of surgical intervention
for example, skin incision

Have all team members introduced themselves by name and role?
☐ Yes

Surgeon, Anaesthetist and Registered Practitioner verbally confirm:
☐ What is the patient's name?
☐ What procedure, site and position are planned?

Anticipated critical events

Surgeon:
☐ How much blood loss is anticipated?
☐ Are there any specific equipment requirements or special investigations?
☐ Are there any critical or unexpected steps you want the team to know about?

Anaesthetist:
☐ Are there any patient specific concerns?
☐ What is the patient's ASA grade?
☐ What monitoring equipment and other specific levels of support are required, for example blood?

Nurse/ODP:
☐ Has the sterility of the instrumentation been confirmed (including indicator results)?
☐ Are there any equipment issues or concerns?

Has the surgical site infection (SSI) bundle been undertaken?
☐ Yes/not applicable
- Antibiotic prophylaxis within the last 60 minutes
- Patient warming
- Hair removal
- Glycaemic control

Has VTE prophylaxis been undertaken?
☐ Yes/not applicable

Is essential imaging displayed?
☐ Yes/not applicable

SIGN OUT (To be read out loud)

Before any member of the team leaves the operating room

Registered Practitioner verbally confirms with the team:
☐ Has the name of the procedure been recorded?
☐ Has it been confirmed that instruments, swabs and sharps counts are complete (or not applicable)?
☐ Have the specimens been labelled (including patient name)?
☐ Have any equipment problems been identified that need to be addressed?

Surgeon, Anaesthetist and Registered Practitioner:
☐ What are the key concerns for recovery and management of this patient?

This checklist contains the core content for England and Wales

www.npsa.nhs.uk/nrls

Figure 1.2: An Example of a 'WHO' Checklist Used in the Medical Field (Vats *et al.*, 2010:134)

been developed that provide a framework for judging the methodological quality of randomised trials. Hart & Owen (2005:249) state that important checks are often forgotten when memory alone is relied on to prepare for a general anaesthetic for caesarean delivery and that the use of a checklist has improved this. Simpson *et al.* (2007:185) state that checklists have been used successfully in the Intensive Care Unit (ICU), though Dunn & Murphy (2008:9) explain that medicine is filled with clinical handovers[1] and has the potential for a big medical communication error, especially when practised in an intensive care environment.

After the implementation of a checklist to standardize the withdrawal-of-life-support process in two teaching hospital tertiary care medical-surgical ICUs, approximately 80 percent of the nurses believed the checklist led to improved end-of-life care and withdrawal of life support (Hales & Pronovost, 2006:3). Semel *et al.* (2010:1593) state that using the checklist would both save money and improve the quality of care in hospitals. Inter-professional checklist briefings reduced the number of communication failures, say Lingard *et al.* (2008:12), promoted proactive and collaborative team communication, and Weiser *et al.* (2010:366) found that checklists also saved millions of dollars.

Hales & Pronovost (2006:3) believe that as patient safety and performance improvement become a stronger focus of the medical profession, the use of simple tools such as checklists for error reduction may contribute to better patient outcomes and safety, more effective practices, and more effective use of allocated funds and resources (de Bakker *et al.*, 2008:126). According to Vats *et al.* (2010:133), there was a noticeable improvement in safety processes after the checklist was introduced. Emerton *et al.* (2009:379) say that the work is completed more quickly, with less effort and better outcomes.

1.5 Formula 1 Racing

F1 provides a series that allows various car manufacturers to showcase their technology and cars (Jenkins *et al.*, 2005:21). There are various functions to manage when it comes to F1: planning, organising, leading and controlling. It also requires precision timing in order for it to be effective (O'Connor, 2013:395).

Vivekanantham *et al.* (2014:4) explain that Formula 1 (F1) racing also requires a high level of teamwork, focus and performance, similar to that used in an operating theatre (see figure 1.3).

The safety and quality of patients during handover from surgery to intensive care has been improved through the use of the analogy of a Formula 1 pit-stop (Safdar, 2012:599). Dunn & Murphy (2008:9) explain that Formula 1 racing

[1] Dunn & Murphy (2008:9) defined clinical handover as transferring the professional responsibility and accountability for aspects of care for a patient to another professional group or person on a permanent or temporary basis.

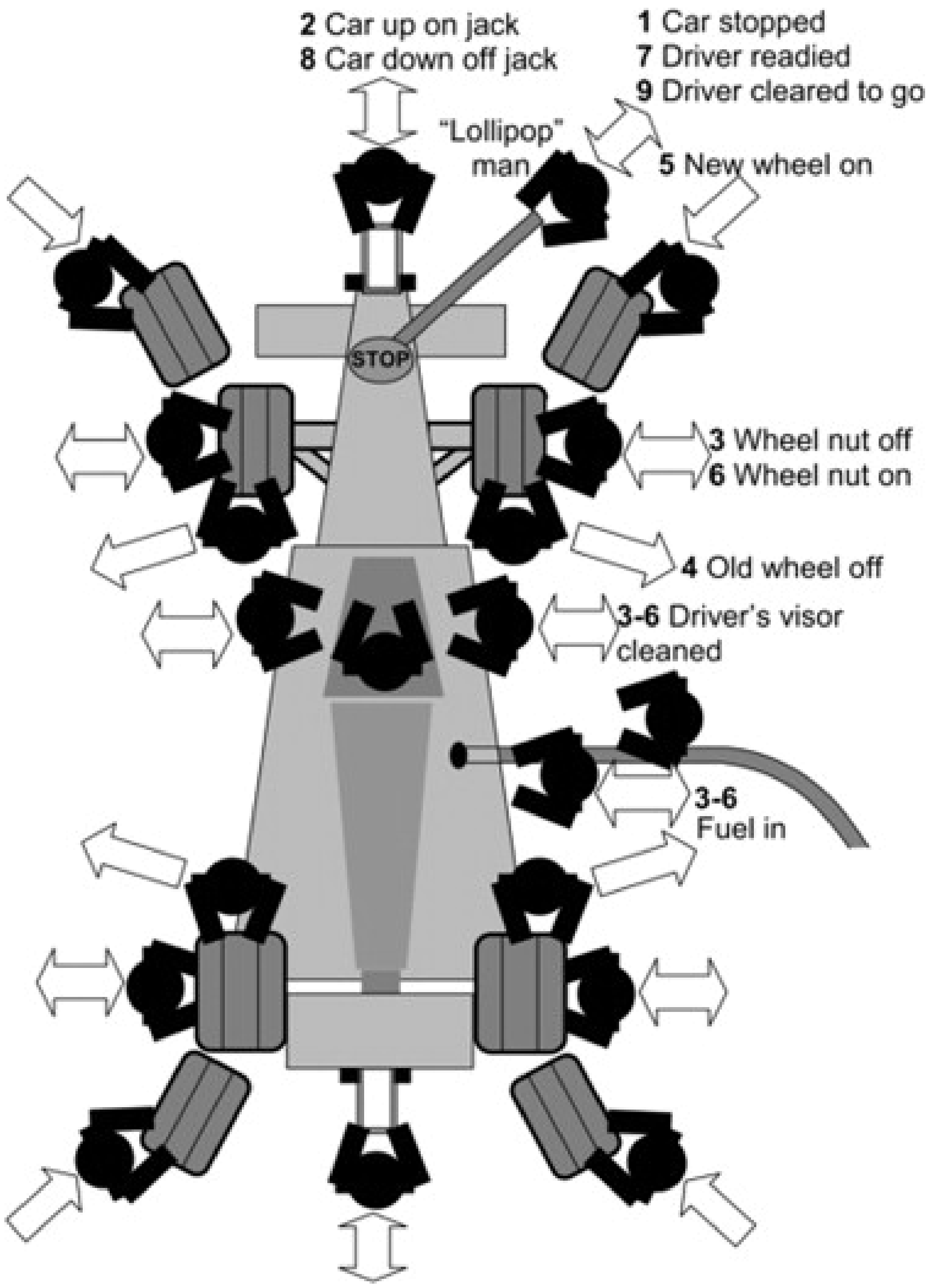


Figure 1.3: An Example of a Formula 1 Checklist (Vivekanantham *et al.*, 2014:4)

car pit crews are known as some of the best "handoff" experts in the world, as errors or delays can cause a driver to lose his life, or determine the race victories. Each team designs their own cars and engines according to specific rules in place to provide the best race performance (Jenkins *et al.*, 2005:21). F1 teams have briefings before every race to ensure each person knows what to check for and accomplish in each pit stop throughout a race (Howard, 1992:47; Catchpole *et al.*, 2007:476).

Jenkins *et al.* (2005:21) explains that Formula 1 is the longest established motor sport championship series in the world. Where F1 pit stops occur for only a few seconds, the audio production process is far more substantive as far as communication is concerned (Chang, 2011:361).

1.6 Checklist fatigue

When creating a checklist, it is of utmost importance that it does not result in checklist fatigue, described by Hales *&* Pronovost (2006:4), as the overwhelming number of available or required checklists become a hindrance rather than an aid. Singh (2009:362) explains that regardless of how many preventative measures are practised, situations of true crisis will ineluctably occur. Although the checklist can offer positive benefits, **?**:1 explain that overuse can lead to checklist fatigue.

Hales *&* Pronovost (2006:4) state that there are risks associated with the overuse of checklists in the medical setting. They believe it is important that checklist development and implementation within an organization be monitored for quality and necessity to avoid overburdening staff. Therefore, **?**:1 advise creating a clear and easy to use document that is adaptable to the context; and prior to implementation, the checklist needs to be tested and based on the needs that are required (Ravindran *&* Vivekanantham, 2014:2).

Burkey *et al.* (1990:4) believe these long checklists increase the possibility of error caused by the accidental omission of checklist items in aviation. In the results of a medical handover study by Salzwedel *et al.* (2013:4), they explain that handovers with the use of the checklist took significantly longer than handovers without the checklist. The results indicate that the checklist contained too many items (Salzwedel *et al.*, 2013:5). According to Burkey *et al.* (1990:4), long aircraft checklists result in pilots spending a great amount of time reading the checklist rather than looking outside for hazards to safe flight. Varble (1972:12) states that a checklist should be short to encourage its use. Thomassen *et al.* (2010:1181) explain that a successful checklist has a clear focus in the planning stages to make the checklist simple to carry out and thus avoid checklist fatigue.

1.7 Adapting checklists to the audio environment

Although it is helpful to draw comparisons from other industries, ultimately audio production studios are unique as there is very seldom a life threatening risk. By researching the standards of other industries checklists adopted from other fields can improve studio work-flow, although not all requirements can be directly translated into audio production. Therefore, material gathered and learnt from other industries forms a foundation upon which improvements to audio production can be made. The following research will show how audio production teams provide a consistency of process comparable to what occurs within the aviation, product manufacturing, Formula 1 and medical fields. It will determine whether it is possible for a similar checklist to be as effective in audio production recordings, which are also becoming more complicated by the day.

Chapter 2

Audio Production Sound Concepts

This chapter will investigate audio production and the research thereof. Audio technology will continue to become more powerful, virtual and portable (Huber, 2014:621). Audio production specifically concentrates on microphone techniques, recording, editing, mixing and mastering (Holman, 2010:49). Once an idea is in place, the goals and objectives have to be decided, followed by the assessment of the target audience in order to determine the style of the project (Reese *et al.*, 2009:6).

Catchpole *et al.* (2007:476) explain that in Formula 1, the 'lollipop' man coordinates the pit-stop; similarly, in aviation, the captain has command and responsibility. The audio production studio also has a position where someone is in control of the process; this would be the role of the audio producer (Hughes *et al.*, 2004:23). Audio producers are compared to film directors (Stone, 2000:5), as they take on a similar role by "directing" the recording procedure. Producers can use their creative abilities to express sounds of various emotional feeling (Burgess, 2005:278; Williams, 2006:630). The creative contributions of audio producers are increasingly important in defining the sound of various artists, groups and styles (Tzanetakis *et al.*, 2007:1).

The sound engineer, also known as recording engineer, has the responsibility to keep the sessions running smoothly, says Crich (2010:1). Sound engineers are focused on recording, whereby they capture the sound, and mixing, whereby they shape the sound (Corey, 2010:4). During the recording session, the engineer needs to listen for quality and performance factors, watch the level indicator controls and faders to keep from overloading the media, and catch any mistakes that the producer might have missed (Huber, 2014:591). Crich (2010:1) explains that this includes the setting up of the control room, organizing the signal flow, choosing the correct microphones, deciding on the track layout, and the actual recording procedure. Sound engineers also need to be familiar with the market as the sound of mixes used in various genres and individual instruments changes (Stone, 2000:24; Zager, 2006:272).

Langford (2014:20) explains that an audio editor often has the task to remove background noise, correct the pitch, compile the best take, ensure that the timing is correct or apply time-stretching, remove unwanted noise and often apply spectral editing. Effectively, an audio editor will clean, fine-tune, optimize and polish the audio files (Langford, 2014:21). Pejrolo (2005:293) explains the importance of listening to the mix many times to understand the problems, in order to find solutions using tools that are available.

Today, the audience is much larger for recorded music than for live musicians, and therefore the sound of the recording is most important (Moorefield, 2010:xvi). Engineers have to be on the cutting edge of the contemporary music scene as their involvement in music is essential to achieving success (Menasché, 2002:6; Zager, 2006:271).

2.1 Frequency

Frequency is the rate at which any kind of motion repeats itself or the number of cycles that occur in a given period of time (Bohn, 2000:4; Rayburn, 2011:9). The frequency of a sound wave is determined by the oscillating rate produced from the source (Everest, 2009:1); this is measured in cycles per second (cps) or hertz (Hz). Wavelength is described by Case (2007:3) as the distance travelled in one cycle. A period is the amount of time it takes for one cycle to occur; it forms a wavelength by reiterating a successive distance in the basic waveform (Rayburn, 2011:9).

The audio spectrum is the frequency range that the human ear is capable of hearing (Reese *et al.*, 2009:32). This is often between 20Hz and 20KHz, although there is definite variation between individuals, with hearing sensitivity gradually declining with age (Crich, 2010:17). The higher the pitch of the musical sound heard, the higher the frequency (Corey, 2010:42). Each sound is often given its character by the frequencies that are involved, their relative frequencies, and the manner in which the frequencies or intensities vary with time (Loy, 2006:225; Stark, 2005:21).

2.2 Amplitude

The resonance of an instrument being played causes vibrations in the small particles of air that is effectively driven to our eardrums through a chain of events that start a distance away at the sound source (Case, 2007:3). Sound is effectively a wave motion in air (Everest, 2009:1). Air particles pull and push against one another acting similar to a spring system; causing a chain reaction throughout the space between the sound source to the ear, which then leads to the perception of sound (Case, 2007:3).

Amplitude relates to the volume of the sound when it reaches the ear (Rumsey, 2009:2). When an object vibrates, it causes the air surrounding it to move, producing sound (Rumsey, 2009:1). An increase of volume, will increase the pressure causing the particles of air to squeeze tighter together; decreases in volume will decrease the pressure, resulting in the air particles pulling apart (Case, 2007:4).

2.3 Reflection and Absorption

When a sound wave strikes an object, it can be reflected, absorbed or refracted by the object (Avison, 1989:457). When building a concert hall, it is important to take the acoustics into consideration by avoiding hard and smooth materials on the inside walls, in order to avoid the reflection of sound (Barron, 1993:196). When the sound is reflected off an uneven surface, sounds can be perceived from many parts of the room, producing a full and lively sound (Avison, 1989:454). The ceilings and walls can also be made of acoustic tiles, fibreglass or softer materials to greater the ability in absorbing sound where required, resulting in pleasing acoustic properties (Barron, 1993:15).

When a sound wave is absorbed, part of the energy from the sound wave converts to heat energy in the material; the remaining energy is simply transmitted right through (Robertson, 2003:65). The amount of energy that is transformed into heat energy differs with the type of material as each material has different absorbing properties (Leonard, 2001:184).

When sound waves reflect off of a surface an echo will occur (Avison, 1989:471). The difference between echoes and reverberation is that echoes are delayed and scaled copies of a source (Nichols, 2013:90). Reverberation is a set of echoes that are generated recursively (Loy, 2006:167). Sound reaches you in three different ways: direct sound, where the sound waves travel directly from the source to the listener; early reflections, where the sound reflects off a close surface, and reverberations, where the sound reflects off multiple surfaces Harris (2012:10).

When a sound wave passes from one medium to the next, the direction, speed and wavelength of the wave changes as well; resulting in refraction (Avison, 1989:457). When the temperature reduces in heat with height, sound speed similarly decreases with height (Avison, 1988:416). When a sound wave travels close to the ground, the section closest to the ground travels faster than the section of the wave that is farthest above the ground (Sen, 1990:137). This results in the wave bending upwards, therefore changing direction (Breithaupt, 2000:324). This often creates a region where in the sound wave cannot travel, called a shadow zone (Avison, 1988:416). If a listener is in the shadow zone, no sound would be heard from the source, even if the source is in sight (Sen, 1990:137). The sound waves refract upwards, never reaching the listener (Breithaupt, 2000:324).

2.4 Speed of sound

When referring to the speed of sound, it is determined by how fast the energy is passed from one particle to the next (Moravcsik, 2002:75). The equation that can be used is speed=distance/time (Crocker, 1998:64). It is defined by the distance that a wave travels per unit of time (Tohyama, 2011:102). This will result in a larger distance covered if a wave travels faster in the same duration of time; and a slower moving wave will cover a smaller distance (Zitzewitz, 2011:166).

The speed of sound is also affected by the medium properties that the wave is travelling through (Moravcsik, 2002:82). Gases have the weakest interactions between particles, followed by liquids and then solids (Zitzewitz, 2011:167). A sound wave will travel faster in particles of less density (Zitzewitz, 2011:166). When a sound wave travels through air, the speed is determined by temperature, and humidity (Tohyama, 2011:31). The temperature will affect the particle interactions' strength (Moravcsik, 2002:82). Humidity will affect the mass density of the air (Crocker, 1998:68). At 20 degrees Celsius, and with the atmospheric pressure at sea level , a sound wave travels at 343m/s (Crocker, 1998:64).

2.5 Psychoacoustics

Psychoacoustics refers to the subjective response to what is perceived as sound (Zwicker, 1990:60). It is the study of scientific, physical and objective properties that encompass them, as well as the psychological and physiological responses evoked by them (Fastl, 2007:150). It focuses on the connection between auditory system physiology, acoustic sound signals and the psychological impression of sound (Harris, 1974:51). This tries to explain the auditory response of listeners and the abilities of the ear in connection with the brain (Howard, 2009:79).

The human ear is effectively a transducer that converts sound energy to mechanical energy, then to a nerve impulse which is transmitted to the brain (Kumar, 2008:261). The pitch[1] of sounds are perceived by detecting sound wave frequencies (Turnbull, 2013:9). The volume[2] of sound is detected by the wave's amplitude (Sherwood, 2007:217). The timbre[3] of sound is distinguished by the various frequencies that form sound waves (Bernstein, 2014:99).

[1] In psychoacoustics, the term pitch refers to the psychological perception of frequency (Zwicker, 1990:120). In music, sound can be arranged on a scale from lowest to highest (Fastl, 2007:163).

[2] Volume is the perception of the intensity of sound, extending from quiet to loud (Howard, 2009:95).

[3] Timbre refers to a listener distinguishing the difference between two sounds in their pitch and volume, often determined by the attack to decay envelope (Howard, 2009:268).

Each component of the ear has a specific task when detecting and interpreting sound (Turnbull, 2013:9). The outer ear collects and channels sound to the middle ear (Sherwood, 2007:219). The middle ear transforms the energy of a sound wave into the inner vibrations of its bone structure and converts these vibrations into a compressed wave in the inner ear (Bernstein, 2014:98). The inner ear converts the energy of a compressed wave within its inner ear fluid into nerve pulses which can then be transmitted to the brain (Kumar, 2008:258).

Pitch is determined by a collection of hair cells where the maximum excitation occurs along the basilar membrane (Howard, 2009:95). This membrane moves up and down, synchronising with the sound wave's variation in pressure (Fastl, 2007:163). A singular up-down movement is equal to one neural firing[4], resulting in the frequency coding directly to the rate of firing[5] (Pressnitzer, 2005:476). The auditory nerve then takes electrical impulses from the semicircular canals and the cochlea and connects with both of the auditory areas of the brain (Fastl, 2007:26). The right and left brain halves differ in their capacity for detecting sound (Gelfand, 2009:35). The left cerebral hemisphere processes verbal information, resulting in the right ear being superior for speech; whereas the left ear better perceives melodies as the right brain half processes non verbal information (Nakagawa, 1995:7).

2.6 Modes of instruments

2.6.1 Strings

A string instrument often has a hollow body, allowing the sound to vibrate inside, but the part of the instrument that produces sound is the strings, made of steel, nylon or gut (Fletcher, 1998:272). Musicians can either draw a bow across the instrument, pluck, or strum the instrument to initiate the sound (Rossing, 2010:3).

Stringed instruments are dependent on the tension and thickness of the string (Bajaj, 1984:253). The string's vibrations are transferred to the resonance box through the bridges as well as the actual sound waves entering the box (Mittal, 2010:359). The combination of the sound board and hollow box structure of the instruments provide amplification (Howard, 2009:171). The

[4] The auditory nerves firing frequency is high at the arrival of sound, then quickly reaches a steady state value known as the burst response. The firing frequency will also go up with the increase in sound pressure. Neural firing is effectively a discharge that synchronizes with a specific phase of the sound stimulus. When this phenomenon occurs, it is called phase lock, where the usual temporal regularity is perceived in firing patterns of nerves from reoccurring sound stimuli. (Nakagawa, 1995:116)

[5] For example, a tone of 250Hz results in hair cells firing 250Hz per second (Pressnitzer, 2005:476).

exception would be electric guitars that generate vibrations on the strings and electronically amplify them (Howard, 2009:180).

Strings are clamped rigidly at both ends in order for the string to generate sound through transverse vibrations of standing waves all along the string (Bajaj, 1984:253). This causes the same frequency of longitudinal vibrations in the air (Howard, 2009:172). Both ends of the strings are fixed, resulting in both ends being nodes (Chaudhuri, 2007:228). Antinodes would therefore be set up along the string (Smith, 2010:219). The basic pattern has a single antinode in the centre, resulting in a node-antinode-node pattern that forms half a sine wave (Bajaj, 1984:275). Therefore, the length of a string equals to half of a wavelength of this frequency, which is the first harmonic[6] (Chaudhuri, 2007:228).

The next pattern has one standing wave along the string (Sen, 1990:58). On the same string, physical length is equal to the wavelength, resulting in the first overtone (Howard, 2009:172). This frequency is at twice it's basic pattern, resulting in the second harmonic (Mittal, 2010:382). The pattern continues as the second overtone has triple the frequency of the fundamental pattern, resulting in the third harmonic (Chaudhuri, 2007:228).

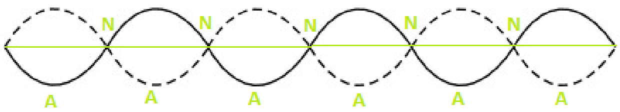


Figure 2.1: An Illustration of a Vibration of a String (Capstick, 2013:169)

2.6.2 Wind Instruments

Wind instrument such as flutes, penny whistles, recorders and some organ pipes consist of open tubes (Howard, 2009:187). Wind instruments such as digeridoos, trumpets, clarinets, trombones and some organ pipes consist of closed tubes (Mittal, 2010:400). These two types of pipes have longitudinal displacement standing waves that are generated inside, governed by the open end, that equates to antinodes and the closed end, which equates to nodes (Howard, 2009:181).

When playing a trumpet, the performers clamp their lips closed resulting in this end representing a node (Ingard, 1988:223). The opposite happens with the flute as the players lips blow over an open hole, forming an antinode of air movement (Howard, 2009:192).

Whistles, recorders and organ pipes use a fipple, which results in a sharp edge that cuts the air flow into the body of the instrument (Howard, 2009:183).

[6] also known as the fundamental (Chaudhuri, 2007:228).

The internal air freely oscillates in and out as this antinode area is open to the air (Mittal, 2010:400).

Similar to strings, the length of open pipes can fit half a wave in the fundamental mode (Ingard, 1988:242). This is governed by the length of the pipe, resulting in a node in the middle and an antinode at each end (Mittal, 2010:400). The first overtone will have a whole standing wave along the length of the pipe, resulting in two half wavelengths and the second harmonic (Howard, 2009:193). Similarly, the second overtone with its three half wavelengths, resulting in the third harmonic. The ratio of frequencies in an open pipe will therefore read as 1 : 2 : 3 : 4, etc.

Closed pipes will always have stationary air at the closed end, and oscillating air at the open end, resulting in a node at the closed end and an antinode at the open end (Chaudhuri, 2007:175). Odd multiples of wavelength quarters will thus be produced in the pipe (Mittal, 2010:400). A whole standing wave fitting in the pipe will result in the first harmonic frequency (Howard, 2009:201). The first overtone will have three quarters of a whole standing wave, resulting in the third harmonic (Mittal, 2010:400). For the closed pipe, the ration will read 1 : 3 : 5 : 7, etc. (Chaudhuri, 2007:175).

Sound waves in pipes are also referred to as pressure waves as the position

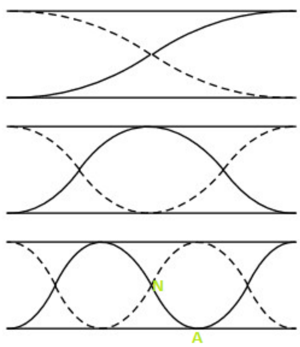


Figure 2.2: An Illustration of an Open Pipe Vibration (Capstick, 2013:169)

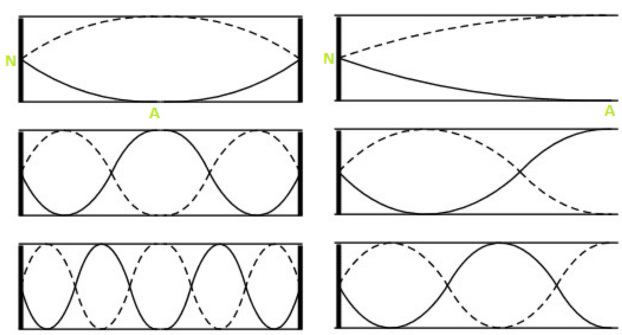


Figure 2.3: An Illustration of a Closed Pipe Vibration (Capstick, 2013:169)

of the nodes are effectively in places where the air is squeezed up to that spot (Howard, 2009:201). When the velocity is changed, it implies an acting force, resulting in pressure antinodes (Chaudhuri, 2007:175). These points are effectively the centres of oscillations, which occur as places of zero pressure (Howard, 2009:201).

Chapter 3

Audio Production Studio Tools

3.1 Microphones

E. E. Wente developed the first wide range and high quality microphone at Bell Labs which was the measured standard in the late 1910s (Fielding, 1983). The rapidly growing recording and radio broadcast industries forced high-quality microphone developments to fluctuate rapidly over the years, resulting in the very high quality microphones that are present today (Eargle, 2004).

A microphone is a device through which sound waves generate an electric current for the purpose of transmitting and recording sound (Rumsey, 2009:564). Although microphones are designed for this function, different types of microphones are designed in order to capture audio in different ways. The three most common types will be described below.

3.1.1 Operating Principles

3.1.1.1 Condenser microphones

Condenser microphones use an electrical element called a capacitor (Thompson, 2005:17). Therefore, a condenser microphone is often referred to as a capacitor microphone. A capacitor microphone's diaphragm has one plate of a capacitor and another plate fixed parallel to the diaphragm (Eargle, 2004:26). There is a small gap between the plates in order to let air pass through (Sinclair, 2001:127). The back plate is often perforated, in order to intensify the resonant frequency (Atkinson, 2013:51). When there is a variation in air pressure in the gap between the diaphragm and the backplate, the electrical capacitance of the capsule also changes (Eargle, 2004:26). When there is a fixed electrical charge across the capsule, the voltage on the diaphragm is adjusted by the sound pressure, producing an electrical signal (Atkinson, 2013:51). This electrical signal is amplified by circuitry inside the microphone, resulting in the phantom power source of the microphone charging the capsule and driving the pre-amplifier circuitry (Eargle, 2004:26). This microphone uses phantom power to supply polarizing voltage to the element and powers the internal pre-amp in the microphone (Thompson, 2005:17). This current is the electrical representation of the original sound wave (Melin & Castillo, 2007:1544).

3.1.1.2 Dynamic Microphones

The dynamic microphones can handle high sound-pressure levels (SPL) (Leach, 2003:106). In dynamic microphones, the coil is inside a magnet, so that when the diaphragm moves, the coil moves simultaneously within the magnetic field, creating an electrical current inside the coil, equal to the original acoustic waveform (Rumsey, 2009:48; Thompson, 2005:14). This current feeds to the output of the microphone through wire leads. This process of converting mechanical and magnetic energy to electrical energy is called electro-magnetic induction (Thompson, 2005:14; Goode & Glattke, 1973:24). In order to control the amplitude of the resonant response peak, damping is used in the transducer diaphragms, ensuring an even response in resonance (Rumsey, 2009:48).

3.1.1.3 Ribbon Microphones

The ribbon microphone A ribbon dynamic microphone does not use a coil (Leach, 2003:110). Instead, it derives it's name from the thin sheet of metal inside the microphone that detects the incoming sound (Whitaker, 2005:279). This sheet of metal is suspended inside a permanent magnet (Crocker, 1998:1415). Air pressure changes move the ribbon, causing the motion inside the magnet to induce a small voltage as the ribbon vibrates (Kefauver, 2001:50). A ribbon microphone has an output transformer built-in to raise the microphone's output impedance level (Kefauver, 2001:50).

3.1.2 Directionality

Microphones also have different types of directional patterns used to capture sound. This polar pattern determines the way that a microphone responds to sound coming from various directions (White, 2012:64). It also dictates from which direction the microphone will capture sound (Makita, 1962:1537). The three most common patterns will be explained below.

3.1.2.1 Cardioid

The word "cardioid" is derived from the shape of the captured pattern on a directional microphone (Bartlett, 2014:126); it vaguely resembles an upside-down heart. Sounds in front of the microphone are predominant, sounds occurring on the sides of the microphone are much lower in volume and sounds behind the microphone are barely picked up (Makita, 1962:1537).

When referring to a capacitor microphone, these variable-pattern microphones often have a dual-diaphragm design, which has two diaphragms fitted on opposite sides of a backplate (Eargle, 2004:347). Each side of the capsule will result in a cardioid response (Sinclair, 2001:127). In order to produce another polar pattern, the signal level of one of the capsules needs to be varied (Atkinson, 2013:51). The varied diaphragm can be connected to a switch, allowing it to be positive or negative (Eargle, 2004:26). By reversing the voltage of the diaphragm, the phase of its output is also reversed (Sinclair, 2001:127). If both capsules are polarised with the same voltage, the outputs merge in order to form an omnidirectional response (Atkinson, 2013:51). This results in the opposing cardioid patterns to be electrically in phase with each other (Eargle, 2004:26).

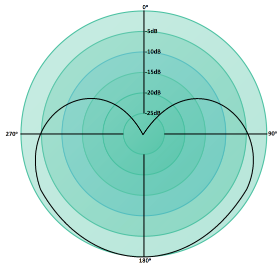


Figure 3.1: An illustration of a cardioid pattern

3.1.2.2 Omnidirectional

Omni-directional microphones are known to be non-directional as they capture sounds evenly from all directions (Thompson, 2003:14). The polar pattern for this particular microphone also functions with frequency. The response is therefore considered to be a three dimensional sphere, apart from where the microphone itself gets in the way of capturing sound (Soede *et al.*, 1993:787).

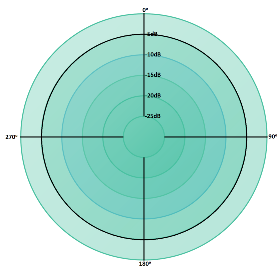


Figure 3.2: An illustration of an omnidirectional pattern

3.1.2.3 Bidirectional

A ribbon microphone uses a bidirectional pattern, also known as a figure-of-8 pattern as it exhibits a frequency response identical in the front and back (Crocker, 1998:1416). This allows the microphone to detect the sound source as well as the ambience of the sound created in the room (Whitaker, 2005:280). Here the condenser element acts as a receiving transducer or a sending transducer, with equal efficiency in the two directions (Rayburn, 2011:140). Therefore, the microphone responds to the pressure-gradient between the two sides of the membrane (Eargle, 2004:16). When sound wave run parallel to the plane of the diaphragm, they produce no gradient pressure (Crocker, 1998:1371). Thus, developing the figure-of-eight directional characteristics. The output voltage is therefore proportional to the air particle velocity (Eargle, 2004:16).

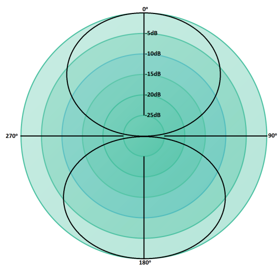


Figure 3.3: An illustration of a bidirectional pattern

3.2 Loudspeakers

A loudspeaker also has a diaphragm that vibrates in order to produce sound waves (Howard, 2009:367; Rumsey, 2009:80). Particular speakers use a cone, moving coil and a powerful magnet, kept in a rigid structure in order to maintain the alignment. It operates in the exact reversed process of the moving-coil microphone. The cone vibration effectively produces sound waves acoustically in the air, replicating the electronic input signal.

Sub-woofers require internal volume cabinets that handle only the deep bass frequencies in order to obtain a good bass response (Rumsey, 2009:91). They are driven by their own amplifiers and produce low frequencies, making a large difference to the weight and scale of sound (Howard, 2009:50).

A speaker cannot be seen in isolation, it is coupled to the room acoustics. Therefore, loudspeakers are normally placed against or close to the walls of the studio or control room, forming an equilateral triangle as the room gain can affect the reinforced low frequencies (Howard, 2009:367). Digital signal processing in loudspeakers compensates for non-linear and linear distortion that arises (Rumsey, 2009:100).

3.3 Amplifiers

An amplifier's sound is portrayed in varying electronic current (Self, 2009:332). It intensifies the audio signal into a larger current while retaining the same pattern of charge fluctuation (Cordell, 2011:164). Effectively, the amplifier produces a more powerful version of the audio signal. This signal needs to be powerful enough to drive a speaker (Self, 2009:241).

The output circuit, generated by the power supply of the amplifier, draws energy from a power outlet or battery (Self, 2009:155). The power supply effectively directs the current into an uninterrupted, even signal (Cordell, 2011:164). The input circuit is the electric audio signal which runs from the microphone (Rumsey, 2009:345). Through varying resistance to the output circuit, voltage fluctuations are created of the original audio signal (Self, 2009:155).

Thus, power amplifiers provide voltage amplification by transforming line levels that measure up to a volt into a higher voltage (Howard, 2009:234). The actual sound power level is measured in watts (Howard, 2009:23). Sensitivity is measured by how much voltage input is necessary in order for the amplifiers' maximum rated output to be produced (Rumsey, 2009:345).

Amplifiers are divided into different classes. In short, Class A would entail a single ended amplifier that limits an output signal to the current range or specific voltage (Fette, 2008:734). A class B amplifier get it's nickname "push-pull" from the 180 degree phase relationship that the outputs have with the active devices, conducting more than half of the input signal swing (Dowla, 2004:184). Class C amplifiers are mostly found in radio-frequency applications, conducting a short portion of every input cycle (Whitaker, 2002:17). Class D amplifiers are often used in cars and personal audio devices as the battery life lasts longer due to the fact that it only uses an output square-wave which switches the frequencies between high and low levels in correspondence with the human auditory range (Fette, 2008:749).

3.4 Mixing Console

An audio production console has many input modules. These modules are identical, and contain many circuits to deliver functions on a signal from the input (Rumsey, 2009:109). A central control unit is connected to each of the modules; this controls selected circuits of the units, to control the working of the module (Franks *&* Langley, 1989:1). A digital recording console uses computer technology to route the audio signal (Rumsey, 2009:109). The audio signal is converted to the digital domain (binary) (Franks *&* Langley, 1989:1). Many mixes can be recorded and recalled without altering the original mix (Zager, 2006:242).

Mixers provide phantom power for capacitor microphones, filtering and equalizing, pan control as well as the general mixing process (Rumsey, 2009:109).

When referring to a recording mixer or mixing console, Fitzmaurice & Buxton (1997:2) define it as an electronic device for mixing and editing audio files. An audio mixer effectively combines many incoming signals into one output signal (Rumsey, 2009:109). Here an engineer can change the level, routing, dynamics and timbre of audio signals (Fitzmaurice & Buxton, 1997:2). Each signal has to be isolated with individual level control as the signals may influence each other (Rumsey, 2009:109).

Mixing consoles often provide sound signal processing through routing to external process devices, or simply on-board (Fitzmaurice & Buxton, 1997:2). Various switches change signal paths or the operational mode of the actual console (Zager, 2006:242).

3.5 Digital Audio Workstation

A Digital Audio Workstation (DAW) is a digital system used for recording and editing digital audio (Alten, 2014:151). This refers to audio hardware as well as audio software. Integrated DAWs were most popular between the 1970s and 1990s (Reese *et al.*, 2009:44). These hardware units included a mixing console, an analog to digital converter (ADC) as well as a data storage device (Alten, 2014:153).

Although these DAWs are still used today, computer systems with digital audio software are more frequently used (Langford, 2014:9). In most professional recording studios, a large mixing board is connected to a desktop computer with audio software, recording interfaces and programs (Sauls, 2013:44).

CHAPTER 4

Audio Production Studio Flow

The audio production process chain follows the structure displayed below (Izhaki, 2012:73):

Figure 4.1: An Example of a Production Chain

4.1 Songwriting

Songwriters are often employed by performing artists, Artist and Repertoire (A&R)[1], music publishers, or serve as their own publishers where they hold the right to grant permission to buy, sell or transfer, by following the laws regarding

[1] The A&R is responsible for talent scouting, managing the development of artists or songwriters, and acting as a liaison between the record label or publishing company and the artists (Flanagan, 2000:237).

copyright (Braheny, 2006:229). This requires knowledge of the music business as well as an understanding of modern music technology (Blume, 2008:170, Peterik, 2010:199). When songwriters sign an agreement with a publisher, their songs are often published by that company, with no exception to be published elsewhere (Braheny, 2006:229).

Songwriting is often an instinctive and creative skill, often inspired by a particular emotion; although a form and structure is needed in order to follow a melodic and lyrical direction (Blume, 2008:3; Peterik, 2010:61). This leads song writing to be closely linked to composition (Jarrett, 2008:138). When composing, one needs to use skills that include the practice of music theory, writing of musical notation and adding the right instrumentation (Jarrett, 2008:52). Both songwriters and composers need to ensure that the instruments chosen will complement each other (Witmer, 2010:28).

Popular songs are often structured on a series of chords in relation to a tonal centre which are all chosen in reflection of a specific emotion (Peterik, 2010:170). Melodies are the succession of single notes in music and harmonies are the combination of simultaneously sounded notes; together the melody and harmony add depth and embellish the music (Witmer, 2010:28). The lyrics are often dependent on a themed melody and sections are alternated between verse and chorus with a bridge often placed before the final chorus (Blume, 2008:10). The verse, chorus and bridge usually have different chord progressions (Witmer, 2010:24).

4.2 Arrangement

An arranger often has to take a deep look into the formal structure, voice leading, harmonic progression, voicing techniques in more than one part, reharmonization, chord substitution, modulations, non-harmonic solutions, introductions, stylizing a melody, interludes, endings, and distancing oneself from the composition in order to consider the big picture (Edstrom, 2006:338).

An arrangement will determine which instruments will be used, throughout which section of the work and in what style (Izhaki, 2012:30). An arranger also needs to find a balance between inventiveness and familiarity (Edstrom, 2006:339).

When arranging music in studio, a combination of instruments, samples and software synthesizers can be combined in order to create a sound style that relates to different music genres (Zager, 2012:59). These arrangements can be used for recording, playback, live shows, backing tracks or for the final production (Hull, 2011:201).

Constructive criticism helps refine a musical statement. With the help of colleagues, criticism can also contribute towards a successful arrangement (Edstrom, 2006:358).

4.3 Recording

Mathes & Sting (2010:9) state that every song goes through metamorphoses as it is being recorded, resulting in one recording session never being exactly the same as another. The process of recording is to convert the electronic signal into a form that is to be stored on a medium from which it can be played back and thus converted to an electrical signal (Holman, 2010:49).

Software tools are widely used in audio recording and production (Sabin & Pardo, 2009:435). High capacity hard drives are used for the storage, retrieval, and manipulation of audio and video information (Zettl, 2010:20). These hard drives have replaced video tape for the storage and playback of audio. A modern control room found in a recording studio is fitted with monitor speakers that are arrayed to symmetrically hear the stereo imaging of the recordings (Rayburn, 2011:273).

A channel is considered to be a signal path and the space on the medium for the audio representation of sound is considered to be a track (Holman, 2010:49). A click track is described by Moorefield (2010:113) as an electronic metronome that is usually recorded onto a track and fed to the artist's earphones to keep in time. An SMPTE Time code is described by Fisher (2005:32) as an acronym for the Society of Motion Picture and Television Engineers. He explains that it is often used to reference a timecode[2]. The format of SMPTE is hours:minutes:seconds:frames (Rumsey, 2009:454). This time code is used for spotting when composing audio projects in order to keep musical events in synchronization with the scene action (Fisher, 2005:32).

4.4 Editing

Editing is the final stage before the mixing process. Izhaki (2012:31) states that it can be divided into selective editing and corrective editing. In selective editing, he explains that the right takes are chosen out of all the recorded material and then the comping[3] practice occurs.

Izhaki (2012:31) explains that in corrective editing, a bad performance is repaired. This includes pitch correction, tuning, fixing time errors like quantizing the drums to a precise metronome tempo, or using the "snap to grid" function (Bartlett, 2013:8).

Langford (2014:241) states that when using computer-based shifting, the first option is usually to quantize, which automatically tunes the output of the processor to the closest correct note. He also explains another way, which is

[2] A timecode is the assignment of time values to frame based media (Fisher, 2005:32).

[3] Langford (2014:89) explains that the process of comping is to put together a single master take from multiple alternate takes, using the best pieces from each to form one final version.

to use Auto-Tune, which automatically corrects the pitch to either diatonic or chromatic scales of monophonic signals.

Langford (2014:47) states that fades and cross-fades are used to smooth the beginning and end of audio regions to avoid unexpected glitches often caused by clipping. He explains that if regions are not overlapping one track, then regular fades would be used. Another commonly performed operation is a cross-fade (Bateman & Christensen, 1990:4), where a controlled smooth transition is made between one audio mix and another. A cross-fade, however, would be used if one region gradually needs to fade into another on the same track (Langford, 2014:47).

When using a fade, the curve also needs to be defined in order to have the correct change in dB over the specified time (Langford, 2014:51).

Audio editing is effectively the manipulation and improvement of sounds and recordings before they reach the mixing stage (Rumsey, 2009:287).

4.5 Mixing

A mix is a presentation of creative ideas, emotions and performance (Izhaki, 2012:5). Mixing involves manipulating digital audio, which is done through a variety of processes, indirectly manipulating sound (Franz, 2004:7; Holman, 2010:49). When referring to mixing, the engineer edits the dynamics processing, levelling the equalisation[4], noise reduction, checking the gain of the instruments in relation to each other, panning, compression, automation, reverberation, and any small details that need correction (Thompson, 2005:10; Izhaki, 2012:24; Katz, 2007:21).

Specific attention must also be paid to calculate the frequency of sound, sound level changes, delay, reverberation, distortion, dynamic processing and spectral irregularities (Corey, 2010:61; Reese *et al.*, 2009:29). Another technical challenge is to conceal the artificial elements to the point at which listeners believe they are hearing a purely natural sound (Hugill, 2012:64). Exciters and enhancers are used interchangeably, as they improve the sound of both instruments, mixes, and masters (Izhaki, 2012:271).

4.5.1 Equalisation

An equaliser (EQ) (Kim *et al.*, 2006:2) is also used to adjust the response of audio until the optimum subjective response is agreed upon by the engineers. Equalisation is an important tool in modern music production; therefore an understanding of how each type of equaliser works is important if one is to choose the most effective EQ for each situation (Alten, 1990:532; Reese *et al.*, 2009:144). Subsequently, the equaliser is used to re-adjust the response to the

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[4] Audio equalizers selectively boost or cut restricted portions of the frequency spectrum, altering the timbre of the sound (Sabin & Pardo, 2009:435).

nearest smooth response correction (Newell, 2008:600). The most common filter circuits in use within equalisers are high-pass and low-pass filters (Alten, 1990:177). A high cut filter[5] will pass frequencies below it's cut-off point as well as attenuate those above (White, 2012:32): therefore a low cut filter[6] will pass frequencies above its cutoff point (White, 2012:32).

4.5.2 Compression

A compressor alters the shape of the envelope by reducing the signal's dynamic range (White, 2012:165). This is done by automatically detecting any changes in level above a set level and riding the gain, therefore keeping the levels more constant (Nichols, 2013:93; White, 2012:44). In order to make the compression less audible, it is used on individual instruments and not the whole mix (White, 2012:166). Limiters are also used in connection with compression in order to limit the signal passing through. The limiters also protect the equipment from overloading (Nichols, 2013:93). Automation is often linked to the audio in order to move with the automation data if necessary (Langford, 2014:13).

4.5.3 Reverberation

When adding reverberation in the mixing process, the sound engineer literally adds an echo effect to the music, as if it was recorded in a room with a lot of reverberation. Another aspect is doubling, where a delay between nine and thirty milliseconds is inserted to make it sound like there is more than one instrument playing the part (Nichols, 2013:93).

4.5.4 Delay

A delay unit (Corey, 2010:72) is used to create echo effects or for effective doubling. This can be done by recording a few singers and adding delay and reverb to the signal, causing the result to sound like a choir (Nichols, 2013:94). It can also be used for positioning instruments. Delay can be useful to mimic the effect which takes a slight difference in time for sound to reach each ear (Loy, 2006:154). This can be done by delaying either the right or left channel. When combined with reverberation, delay can help to produce a three-dimensional mix Edstrom (2006:137). Reverberation is a simulation of sound in a series of delays (Nichols, 2013:94). Sound bounces back from every surface in a room. These reflections create tone clusters for each acoustical environment (Gibson, 1997:93).

[5] A high cut filter is also known as a low pass filter (White, 2012:32).
[6] A low cut filter is also known as a high pass filter (White, 2012:32).

4.5.5 Dynamics

Dynamics in mixing refers to variations in level (Reese *et al.*, 2009:149); the distinguishing factor is between macro dynamics and micro dynamics. Macro dynamics are variations in level for events longer than a single note; this is in relation to the changing level between verse and chorus in factors such as bass notes, snare hits and vocal phrases. Micro dynamics are variations in level that happen within each following note played; this could be the attack and decay of a snare hit. Micro dynamics are associated with the dynamics envelope of sounds (Izhaki, 2012:264).

Decay is described by Crich (2010:17) as the time it takes for an instrument's sound to fade away. It is different for each instrument and pitch. The decay is measured from the release time of the attack until the decay fades away completely (Loy, 2006:368).

4.5.6 Distortion

Distortion (Bohn, 2000:1) refers to any alteration which adds frequencies that are not present in the original sound, or changes the duration of any of those frequencies; or any other characteristic that changes the nature of a sound (Stark, 2005:77). Rayburn (2011:140) explains that distortion is often the result of electrical overload. According to Rayburn (2011:139), distortion present from many studio quality microphones actually results from electrical overload of the amplifier stage. The input signal should not be too high as it may cause clipping when set to its maximum output level. White (2012:34) states that clipping is effectively the squaring off of the bottoms and tops of a waveform. He explains that it is caused by the circuitry that cannot deliver more level, despite how high the gain is turned up. Clipping occurs when an over-driven amplifier attempts to deliver an output current which is beyond its total capability (Case, 2011:70). When the amplifier tries to create a signal with greater power than its power supply is able to produce, the signal will only be amplified to the amplifiers maximum capacity; therefore the signal will not be able to be amplified further (Corey, 2010:111). The signal will then be "clipped" at the amplifiers maximum capacity, simply cutting off the extra signal beyond the capacity of the amplifier (Case, 2011:70). This results in the sine wave turning into a distorted square-type waveform (Corey, 2010:113).

The two main types are harmonic distortion and Intermodulation distortion (Davis, 1989:81). In harmonic distortion, the harmonics of an input signal are created in the amplifier, then materialize in the output together with the amplified signal (Sandlin, 2000:190). In simpler words: Harmonic distortion occurs when an input of a single frequency flows into an amplifier, but the output waveform gets clipped by the amplifier, resulting in harmonic frequencies produced at the output that are not present in the original signal (Whitaker, 2005:1705). If the clipping is symmetrical, this harmonic distortion will only contain odd harmonics (Davis, 1989:81).

Intermodulation distortion (IMD) is specific to a pre-amplifier or amplifier that measures and adds non-harmonic frequencies to the signal (Newell, 2006:454). Intermodulation Distortion occurs when frequencies are generated in the reproduction of music that are not present in the original sound track (Winer, 2012:34). It results in two or more signals that are not harmonic frequencies, mixing together (Toole, 2008:452). Intermodulation distortion is effectively between harmonic frequencies (Newell, 2006:454).

4.5.7 'Signal-to-noise ratio'

'Signal-to-noise' ratio is described by Taguchi (1991:17) as a measure that compares the level of background noise to the level of a desired signal. It is effectively the ratio of signal power to noise power. For example, a ratio which is higher than 1:1 indicates that there is more of the desired signal than the unwanted noise (Utz, 2003:99).

An example of 'signal-to-noise ratio' (Bisping, 1994:1) would be a weak instrument signal that outputs at 10% of its optimal level. At 10%, the noise (Vaseghi, 2008:2) is higher than good signal. When the signal is amplified using a trim control or fader, both the noise and clean signal are raised (Nichols, 2013:95; Kim *et al.*, 2005:5). If the instrument is sending a signal of 90% of its optimal level, there is a much lower percentage of noise; thus when the overall signal is increased at the input stage, the 'signal-to-noise ratio' stays at the appropriate level (Corey, 2010:142; Nichols, 2013:95; Alten, 1990:82).

4.6 Mastering

Mastering is the final process in preparing a recording before manufacturing (Thompson, 2005:10). Here the mastering engineer is responsible for the technical and creative excellence and final equalization process; it almost just adds a final sonic gloss (Zager, 2006:25). The mastering engineer has the responsibility to ensure that the audio quality which leaves the mastering studio is the same quality that will be represented on the final medium. As a mastering engineer, one needs to be able to determine what is lacking and make the recording sound like a polished record and when to leave it alone. Mastering requires attention to detail, musical and technical knowledge, and people skills (Katz, 2007:24). In particular, the techniques pertaining to pre-mastering include macro-dynamics, equalisation, micro dynamics, enhancement, excitation, noise reduction and analogue and digital processing.

Loy (2006:46) states that the very last step performed during mastering is dithering. Dither is effectively quiet noise that has been added to a signal in order to assist the quantizing process (Cousins, 2013:34). It is needed as lower bit rates are not as resolute as a 24 bit file for example; resulting in a possibility that particular waveforms could cause gaps in the accuracy of the conversion process (Strong, 2013:289). Owsinski (2000:46) describes this as a low-level noise signal added to the audio project to trim it to 16bits in order for it to fit on to a CD. Any additional operations performed will undo the benefits of dithering (Loy, 2006:46).

Chapter 5

Studio Documentation

Documentation is described to be communicable material that assists the use of checklists to describe, instruct or explain attributes of a procedure, system or object regarding the use, maintenance, installation, its parts or assembly (Beisse, 2012:98).

When observing another field such as computer software, documentation can also enhance the product's perceived quality, leading to increased profits through increased sales (Steehouder, 1994:178). It facilitates the extending, updating and improving of software (Gyurky, 2006:118).

The actual process of creating documentation occurs in various stages as it can always be improved or corrected (Naveda, 2006:84). Good documentation is easy to use, saves time, money and frustration (Beisse, 2012:98). Documentation used in audio production studios can also vary in many different forms. This chapter investigates, designs and explains the benefits of documentation in the Audio Production Studio in order to help the checklist process.

5.1 Documents

Sheet music is described by Webster (2003:1016) as "music printed on unbound sheets of paper." When recording works with large scores, this involves the artist having many page turns (Borchers *et al.*, 2006:7). There are many pitfalls to orchestral page turning, and in the recording studio with its sensitive microphones, each page turn will be picked up as unwanted noise (Thompson, 2005:14; Bisping, 1994:2). By using electronic scores, page turning can be eliminated (Borchers *et al.*, 2006:2).

Documents such as patch sheets, track sheets, recording logs, take sheets, work order forms and session notes must be carefully recorded to help keep an orderly state in the studio (Carroll, 2005:3). This includes a record of the project, the artists involved, the date the document was filled in, the personnel present, the format, rate/depth, as well as SMPTE (time code) used (Fisher, 2005:32). These documents are very helpful when it is necessary to go back to a specific project (Carroll, 2005:3). The following document examples have been designed and created for this study alone.

5.2 Track Sheet

Mathes & Sting (2010:9) explain that critics and listeners are surprised to hear the alternative versions and studio out-takes that reveal the origin of a well known song. By completing a track sheet, one will keep a record of which effects were used on the various instruments, which microphones were used to capture good guitar riffs, how an instrument was placed in a surround field and general characteristics of what the recorded track entails (Reese *et al.*, 2009:52; McKinnie, 2010; Huber, 2014:591; Børja, 1977:485).

Anonymous Studios: Track Sheet

Project________ Artist________ Producer________

Client________ Sound Engineer________ Assistant________

Format ________ Rate/Depth____/____ Page___/___ SMPTE________

Recording Date________ Notes________

Track 01	Track 02	Track 03	Track 04	Track 05	Track 06
Track 07	**Track 08**	**Track 09**	**Track 10**	**Track 11**	**Track 12**
Track 13	**Track 14**	**Track 15**	**Track 16**	**Track 17**	**Track 18**
Track 19	**Track 20**	**Track21**	**Track 22**	**Track 23**	**Track 24**

Notes________

Figure 5.1: An Example of a Track Sheet

5.3 Recording Log

A recording log is often used to keep track of what was done during the recording process, in such a way that the recording process can almost be recreated (Diamant, 2004:126; Chow *et al.*, 2011:9). This includes note-taking regarding specific happenings that occurred, or any detail that could help the mixing process (North, 2009:124).

Anonymous Studios: Recording Log

Project ________________ Artist ________________ Producer ________________

Client ____________ Sound Engineer ________________ Assistant ________________

Format ____________ Rate/Depth ______ / ______ Page ___ / ___ SMPTE __________

Session ______ Recording Date ________________ Notes ______________________

Track	Start	End	Title/Event	Processing/Notes

Figure 5.2: An Example of a Recording Log

5.4 Take Sheet

Similar to a recording log, a take sheet is also kept at hand during the actual recording session (Abe *et al.*, 1996:26). This document is used for note-taking in connection with each take (Coleman, 2009:15); whether it was a good take or not, if it was just a short part of the music that was recorded (eg. from bar 34-48) to perfect a certain musical idea. This document is kept at hand during the mixing process to see which takes can simply be deleted and which takes need to be edited (Abe *et al.*, 1996:26).

Anonymous Studios: Take Sheet

Project ____________ Artist ____________ Producer ____________

Client __________ Sound Engineer ____________ Assistant ____________

Format ________ Rate/Depth ____/____ Page __/__ SMPTE ________

Tempo ____ Recording Date ____________ Notes ________________

Take	From	To	Notes

Figure 5.3: An Example of a Take Sheet

5.5 Work Order Form

A work order form is used as a written agreement between the studio and the client, detailing the services offered and confirmed (Charney, 1984:133). Once the services have been agreed upon, it is much easier to go back to a written agreement if there are any misunderstandings in the future.

Anonymous Studios: Work Order Form

Project____________ Artist________________________ Producer________________

Client_____________ Sound Engineer________________ Assistant________________

Format ___________ Rate/Depth______/______ Page___/___ SMPTE___________

Date______________ Notes____

Describe work performed:

Description	Units	Hourly Rate	Cost
		Total:	

Figure 5.4: An Example of a Work Order Form

5.6 Patch Sheet

A patch sheet is useful to keep track of and recall where all the equipment is patched in and to which amplifiers and DAWs (Yeung, 2006:143). Mathes & Sting (2010:9) feel that where a song begins and ends up becoming are often in two very different places. At a glance, one can see how the patching was constructed when using a patch sheet, rather than trying to remember afterwards (Zwa, 2013:8).

Anonymous Studios: Patch Sheet

Project ________________ Artist ________________ Producer ______________

Client ___________ Sound Engineer ______________ Assistant ______________

Format ___________ Rate/Depth ______/______ Page ___/___ SMPTE __________

Recording Date ______________ Notes ________________________________

Signal	Microphone	Channel	To	Preamp	Gain	OB ins	DAW i/o	DAW Ch Name

Figure 5.5: An Example of a Patch Sheet

5.7 Session Notes

Session notes reveal the technical and creative decision-making process underpinning a recording session (Brewer, 2000:204).

Anonymous Studios: Session Notes

Project ________________ Artist ________________ Producer ________________

Client ____________ Sound Engineer ________________ Assistant ________________

Format ___________ Rate/Depth ______/______ Page ___/___ SMPTE __________

Session _____ Recording Date ________________ Notes ______________________

Session Notes:

Figure 5.6: An Example of Session Notes

5.8 Performance Lease

Reese *et al.* (2009:11) believe it is important to get the artists involved to sign a performance lease in order to edit their contributions and distribute the project.

Anonymous Studios: Performance Release

Project ____________________ Date______________________ Producer__________________

Client______________ Sound Engineer__________________ Assistant__________________

Please note that this document is not intended for legal use, but only as a representation of a performance release.

I _________________________(Name and Surname) , **on behalf of** ____________________ (Band, Station, Producer, Production Company) **give consent and authority to Anonymous Studios to use this project recording for audio distribution and general purposes mentioned below:** ____

____

____

____

Further, I agree to defend and hold the Anonymous Studios and its personnel not-guilty for any suits or claims during and after the recording process.

Signature _____________________________________

Printed Name _________________________________

Email Address ________________________________

Signed at ______________________________ on the ______ day of _____________ 20____.

Figure 5.7: An Example of a Performance Release

5.9 Time Log

A time log helps one to figure out the proportion of time that is spent in different activities. This could help a lot in sessions, to see how long it took to fix a simple noise issue (Nichols, 2013:97), or the amount of time wasted trying to fix a problem that persists. It also helps to figure out whether tasks are largely being completed in one chunk, have frequent interruptions, or are simply being spread out over longer periods of time.

Anonymous Studios: Time Log

Project ________________ Artist ________________ Producer ______________

Client ____________ Sound Engineer ______________ Assistant ______________

Format ___________ Rate/Depth ______/______ Page ___/___ SMPTE __________

Session _____ Date _____________ Notes ______________________________

Time	Describe Procedure
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Figure 5.8: An Example of a Time Log

5.10 Studio Log

A studio log is a factual listed record of sessions in order of their occurrence (Geldeart & Rodham, 2007:7). The first approaches to recording a song may have been tried and rejected (Mathes & Sting, 2010:10). The studio log should specify what work was done, the time the session started and ended, including the personnel present and the location in order to refer back to at a later stage (Geldeart & Rodham, 2007:7).

Anonymous Studios: Studio Log

Date	Project	Personnel	Time Start	Time End	Location	Procedure

Figure 5.9: An Example of a Studio Log

Chapter 6

The Design of an Audio Production Checklist

The following discussion will detail the considerations in the design and construction of an audio production checklist based on the best practices as proposed by various authors. It depicts why the listed items are included as well as a description of each. This discussion is confined to audio production.

6.1 Checklist Design

Human error is inevitable, particularly under stressful conditions (Reason, 2000:393). Such conditions can lead to increased errors in judgement, decreased compliance with standard procedures, and decreased proficiency (Hales & Pronovost, 2006:231). Before the checklist is ready for practical use, it needs to be evaluated by sound engineers and producers in order to assess the effectiveness and to compare different approaches (Reiss, 2011:5).

List instructions are also often better understood and recalled than information in paragraph format, says (Hales & Pronovost, 2006:232), therefore a list structure has been used. The contents of the checklist are derived from good practices as proposed by various authors and presented as a table.

Noise Reduction	
Notice "Recording in Progress"	Reese *et al.* (2009:27); Read (2007:1)
Remove unnecessary equipment	Crich (2010:24)
Air-conditioner	Kim *et al.* (2005:5)
Traffic	Boucouvalas (1996:345)
Lights	Ishibashi *et al.* (2004:3049)
Service instruments	Pedrick (1998:34)
'Signal to Noise' ratio	Reese *et al.* (2009:147)

Artist Comfort	
Welcome	Franz (2004:4); Bauman (1992:41)
Drinks/snacks	Crich (2010:28)
Music stand	Crich (2010:28)
Seating	Stone (2000:5)
Lights	Greene (2002:16)
Comfortable environment	Sloboda (2000:398)
Good headphone mix	Ward & Burns (2005:116)
Documents	
Sheet music	Webster (2003:1016); Borchers *et al.* (2006:2)
Track sheet	McKinnie (2010); Huber (2014:591)
recording log	Diamant (2004:126); Chow *et al.* (2011:9)
Take sheet	Coleman (2009:15); Abe *et al.* (1996:26)
Work order form	Charney (1984:133)
Patch sheets	Yeung (2006:143); Mathes & Sting (2010:9)
Session notes	Brewer (2000:204)
Performance release	Reese *et al.* (2009:11)
Computer	
Power saving mode off	Zheng & Kravets (2005:2); Guo *et al.* (2001:3)
System sounds off	Boersma & Weenink (2001:342)
Date	Capps & Gannholm (1996:3)
Time	Takai (2002:9)
Local Area Network	
High-speed routers	Chlamtac *et al.* (1992:178)
Network hubs	Corey (2010:136)
Physical Network Cables	Gazsi & Nie (2006:1)
Interconnections to third party networks	Leung (1997:2)
Interactions to the World Wide Web and Internet connectivity	Watro *et al.* (2004:60)
Audio and video content servers in support of all DAW systems and mixing consoles	Huffaker *et al.* (2001:1); Hilton (2002:3)
Digital Audio Workstation (DAW)	
Patch bay	Franz (2004:19); Zager (2006:245)
Set Auto Backups	Bonkenburg *et al.* (2003:1); Brunet *et al.* (2006:1)
Disc Allocation	Austin (1971:378)
Disc Space	Will (2002:1)
Bit Depth	Snyder (2002:4); Whalen (2005:1)
Sample Rate	Snyder (2002:1)
DAW Session	
Time Code layout	(Collins, 2006:343); (Bacic *et al.*, 2004:453)
Duplicate inputs	Mitra & Kaiser (1993:37); Endo *et al.* (1996:3)
Channel names	Johnson *et al.* (2002:2); Bohn (2000:5)
Tracks	Alten (1990:461)
Microphone Placement	
Balancing	Granata *et al.* (2003:36)
Correct technique used	Corey (2010:27); Granata *et al.* (2003:36)
Bleed	Greenwood & Chafe (2013:1); (Middleton, 2008:256)
Stands	Copeland & Elder (2005:1); Blakely *et al.* (2009:1)
Cables	Alten (1990:85); Crich (2010:30)
Mechanical noise transfer	Gabrielson (1993:903); Reese *et al.* (2009:29)
Microphone level	Reese *et al.* (2009:131); Baker & Sarpeshkar (2003:1673)
Safety	Musburger (1998:191)
Pre-amplifiers	
Line level	Franz (2004:12)
Gain	Sims Jr (1995:5); Reese *et al.* (2009:131)
Pads	Britton *et al.* (1992:1304)
Filters	Ho *et al.* (2004:354); Corey (2010:33)
Polarity	Alten (1990:57)

Gain	
Healthy 'signal to noise' ratio	Wolfe & Godsill (2000:821)
Noise floor	Frey (1994:205); Dougherty (1999:16)
Clipping	Zager (2006:245)
Reference (-18/20 dBFS)	Franz (2004:12)
Control Room	
Talk-back	Harrison (2000:3)
Monitor Levels	Putnam (1960:115)
Backup Recorders	
Power supply	Miyara *et al.* (2010:2)
Clock Sync	Loy (2006:11)
Disc Space	Coder (2009:11); Dwyer *et al.* (2003:13)
Verify Routing	Thompson (2005:10)
Start and Restart of Session	
All Tracks armed	Campbell (2013:62)
Signal present - all channels	Vaseghi (2008:2)
Noise absent	Loy (2006:33)
After First Pass	
Check Disk Allocation	Heo (2006:20)
Verify playlists	Van Ryzin (2002:9)
Verify Clip Numbers	Machida *et al.* (1985:7); Arataki *et al.* (1993:11)
All tracks were recorded	Van Ryzin (2002:10); Heo (2006:20)
End of Session	
Make backups	Hagerman (2013:19); Collins (2004:45)
Move backups off-site	Cook (2013:51)
Update Session Notes	Nichols (2013:94)
Time Log	Nichols (2013:97)
Studio Log	Geldeart & Rodham (2007:7)

6.2 Checklist Description

This section gives a better understanding of why each of the points should be included in the checklist.

6.2.1 Noise Reduction

It is important to have lighted signs over the studios' doors that read "On Air" or "Recording in Progress" (Reese *et al.*, 2009:27; Read, 2007:1). The door can also simply be closed with a "recording in progress" sign on it, in order to ensure that anyone walking past will quieten down, and no people will enter unexpectedly (Haidet *et al.*, 2009:468). Any unnecessary equipment should be removed from the studio to avoid unwanted rattles in the recording (Crich, 2010:24). There are many kinds of sounds generated in and around all buildings, such as air conditioners, the hum of lights, traffic noises, and noises generated by building equipment, causing a noise problem (Kim *et al.*, 2005:5; Boucouvalas, 1996:345; Ishibashi *et al.*, 2004:3049). Sound engineers need to think carefully about specific recording techniques to use in order to limit any unwanted noise (Bisping, 1994:1). Instruments also need to be serviced at regular intervals and kept in a proper, neat working condition (Pedrick, 1998:34).

One can also optimize the input levels (Vaseghi, 2008:2; Boyle *et al.*, 1981:6). When recording a line-level sound source such as an analogue synthesizer, Edstrom (2006:126) says it is best to turn up the volume on the instrument and adjust the input trim on the mixer or audio interface. If an instrument sends a good signal, the signal will not need as much amplification at the input stage, resulting in a better 'signal-to-noise ratio' (Reese *et al.*, 2009:147).

6.2.2 Artist or Client Comfort

Welcoming the artists into the studio, serving drinks and snacks, making sure all the artists have the necessary music stands and seats are all aspects that help them feel comfortable, but they also need to feel as natural as possible (Franz, 2004:4; Crich, 2010:28; Stone, 2000:5). They need to feel relaxed, hear themselves naturally, and be able to perform as naturally and normally as possible (Juslin, 2000:1798; Tsay & Banaji, 2011:462). Despite the studio being a different environment than the stage, the goal as engineers and producers is to cater to the musicians' needs in order to capture the best performance possible (Sloboda, 2000:398).

Artists perform at their very best when they feel in the zone, something that happens many times naturally on stage (Deutsch, 2012:98; Juslin, 1997:384). Creating a comfortable atmosphere helps artists relax, making recordings a lot easier (Marchant-Haycox & Wilson, 1992:1062). Also, it is important to make sure that there is enough light for the instrumentalists (Brewer, 2000:202; Greene, 2002:16). Artists need to hear both themselves and the instruments they are playing with clearly (Sloboda, 2000:398). It is thus very important to get a good headphone mix (Ward & Burns, 2005:116). Check the levels as needed and suggest removing one ear from the headphones in order to hear the instrument in "real space" (Corey, 2010:19).

It is hard for artists to perform at their best in the studio (Greene, 2002:14). When recording musicians, the invisibility of an audience removes the channel of communication to express themselves through their body and facial features, which also results in a limited amount of expression portrayed in the music (Katz, 2004:20). The mood set has to be relaxed (Juslin, 2003:282). If an artist is feeling uptight or there is a stifling mood in the studio, that artist is not going to play very well (Deutsch, 2012:98). But if that same artist is feeling comfortable and knows that the engineers are working together, it will result in a better, more sincere performance (Sloboda, 2000:398). It is also very important to listen to artists, understand what they are going through and what they are trying to portray in order to help them navigate the dynamics involved (Palmer, 1997:119; Kim *et al.*, 2006:2).

Each artist is different, so each project is different; the engineer needs to be candid without being hurtful (Juslin, 2003:282). Most of all, the artist needs to shine through; the engineer needs to capture what the artist creates, thus making the artist feel welcome is not just the first step, but a step that follows throughout (Bauman, 1992:41).

6.2.3 Computer

The power saving mode has to be off to ensure that the computer does not enter sleep mode half way through a recording or bounce (Zheng & Kravets, 2005:2; Guo *et al.*, 2001:3). System sounds such as clicks are unwanted on recordings; therefore the system sounds need to be switched off (Kamijo, 2006:6).

It is important to ensure that the correct date and time appear on the recordings; therefore these have to be correct on the computer itself (Takai, 2002:9).

6.2.4 Local Area Network

A Local Area Network must be configured in order to assure that bandwidth requirements are met between their associated tactile work surfaces with a single facility or throughout a Wide Area Network to remote facilities comprising high-speed routers, network hubs, physical network cables, interconnections to third party networks, interactions to the World Wide Web and Internet connectivity, audio and video content servers in support of all DAW systems (see below) and mixing consoles (Chlamtac *et al.*, 1992:178; Corey, 2010:136; Gazsi & Nie, 2006:1; Leung, 1997:2; Watro *et al.*, 2004:60; Huffaker *et al.*, 2001:1; Hilton, 2002:3).

6.2.5 Digital Audio Workstation (DAW)

A patch bay is a routing system for various input and output devices used in the recording studio (Franz, 2004:19; Zager, 2006:245). Interconnections between individual different ports are provided by patching cables or alternatively by means of internal connections in patching panels (Putnam, 1960:115; Reese *et al.*, 2009:126; Krupka & Zisapel, 1996:1). A traceable patch cable is used to transmit signals from one receptacle to another (Angelo *et al.*, 2003:1).

Automatic backups should be set in case the computer crashes while recording or mixing (Bonkenburg *et al.*, 2003:1; Brunet *et al.*, 2006:1).

Every time a new audio track is created in specific audio editing programs, the track needs a hard drive to record to (Van Ryzin, 2002:393). Disc Allocation is therefore very important to check (Ng *et al.*, 2004:725). The Disk Allocation window in specific software packages can help increase the performance of the system by allocating some tracks in the session to another drive attached to the computer (Valenzuela, 2011:83). This reduces the amount of data that has to be recorded to and played back from each drive (Valenzuela, 2011:87).

It is important to check whether or not there is enough disc space to record for the given time allocated as well as keeping extra space spare (Will, 2002:1).

In digital audio production, bit depth is the number of bits of information in each sample (Snyder, 2002:4; Whalen, 2005:1). The most popular samples are 16-bit and 24-bit (Sinha & Tewfik, 1993:3463). Using the 16-bit option generally creates smaller files, adequate for basic recordings for audio CDs (Imai *et al.*, 1997:687). The 24-bit and 32-bit options provide a larger dynamic range in the recorded audio and lower the noise floor (Klar & Spikofski, 2002:4; Beard, 1992:11).

Sampling is the reduction of a continuous signal to a discrete signal (Lin, 1999:3). Sample rate is the number of samples of audio carried per second (Snyder, 2002:1). It is measured in Hz or kHz. Oversampling also occurs where a sampling frequency is more than twice the desired system bandwidth so that a digital filter can be used in exchange for a weaker analogue anti-aliasing filter (Adams & Tom, 1994:481).

6.2.6 DAW Session

If the time-of-day clock is reset or if the time code (TC) mode is changed from 24 hour run to another mode and back, the time code value will change (Collins, 2006:343). It is important to change all time code devices to ensure proper synchronization (Bacic *et al.*, 2004:453).

Inputs need to be duplicated to ensure that a digital signal which is recorded onto a recording medium while being encoded is duplicated to another recording medium without being decoded (Mitra & Kaiser, 1993:37). Endo *et al.* (1996:3) explain that an audio signal should be reproduced using data recorded in a table of contents of the recording medium (Hair, 1993:4). The first data signal, a 2-channel audio signal, is intermittently reproduced from the first area of the recording medium, and a second data signal, another 2-channel audio signal, is intermittently reproduced from the second area of the recording medium during the period in which the first data signal is not recorded (Amoroso, 1980:20).

Channel names help the engineer keep track of which microphone is where, or which plug-in is used (Johnson *et al.*, 2002:2). An example would be: Channel 1 - Vox Bass (Bohn, 2000:5).

Tracks also need to be named for similar reasons, so that the engineer can distinguish between the tracks when mixing (Alten, 1990:461). One has to be careful to select all tracks when moving them around, so that they stay locked together and no phase problems occur. Another option is to use the “Snap To Grid” function when moving unquantised audio around (Bartlett, 2013:8).

6.2.7 Microphone Placement

Each microphone has a unique sound character that is based on its specific design and type (Altman, 1992:26). Many models and types can be used for different applications. One needs to keep an open mind and choose the types and range of microphones that best fit. The placements of the microphones are just as important (Corey, 2010:27; Huber, 2014:136).

A recording needs to maintain a balance, for example: between the volumes of the orchestra and the vocalist, and proper balancing is the result of correct microphone placement and set-up of the orchestra or band in the studio (Granata *et al.*, 2003:36).

When using more than one microphone, the smallest amount of bleed will become noticeable on a recording (Terrell *et al.*, 2010:4). If a microphone picks up two sounds at the same time, it is difficult to separate them later on; so microphones need to be separated and positioned so they only record what they are pointing at (Greenwood & Chafe, 2013:1). Microphones can be separated by screens or isolation booths (Middleton, 2008:256).

Stereo is a changing mix of signals (McCarthy, 2010:488). Stereo microphone techniques can improve the sound in certain situations (Reese *et al.*, 2009:71). This will require two audio tracks, and a choice of many different techniques. Positioning stereo microphones in a room can be difficult, as one needs to consider the sound of the actual room itself and how to make best use of the stereo field (Corey, 2010:28; Middleton, 2008:257).

Microphones are supported on floor stands called microphone stands (Copeland & Elder, 2005:1). They are commonly used to attach and hold or position microphones (Blakely *et al.*, 2009:1). Cables need to be checked to ensure that the correct microphone cables are available and set up in a way that is neat, out of the way and safe (Alten, 1990:85; Crich, 2010:30).

If micro-machined optical microphone structures with low thermal-mechanical noise levels are unavailable, mechanical noise transfer needs to be checked in order for the microphones to pick up everything but the unwanted noise (Gabrielson, 1993:903; Reese *et al.*, 2009:29). A wavelength is the length of a specific sound wave, also described as the space it takes in order to complete a cycle (Ballou, 2013:27). The wave length can be calculated as equal to the speed of sound when the sound speed is divided by the frequency or pitch (Crich, 2010:13). For example: speed of sound (1125 feet per second (fps)) $\div$ frequency (440 Hz) = 2.55 fps. This formula is used to avoid the microphones being “out-of-phase”.

In terms of microphone levels, microphones are connected to pre-amplifiers; the purpose serves to amplify the output of the microphone to an electronic level (Reese *et al.*, 2009:131; Baker & Sarpeshkar, 2003:1673; Holman, 2010:53).

General safety measures also need to be taken into consideration when setting up for a recording (Musburger, 1998:191).

6.2.8 Preamplifiers

Pre-amps raise the microphone signal level to a usable line level (Crich, 2010:35). Line level is effectively the amplitude of an audio signal that keeps to a standard nominal level (White, 2012:34). Line levels are used to connect equipment together for signal processing, says Holman (2010:53); they can be cables connected to the input and output connectors of equipment, or by the use of [1]patch bays (Menasché, 2002:18). One must also check whether the line level is operating at the correct strength of either +4 dBm or -10 dBv (Franz, 2004:12).

A typical microphone pre-amp provides 10db to 75db of gain, either continuously adjustable or switched in discrete steps (Sims Jr, 1995:5). When the gain of the pre-amplifier is high, there is a risk of distortion (Dolby *&* Plunkett, 1977:12; Max, 1960:9). A microphone pre-amp has the function of amplifying the low input voltage to a more common level (Reese *et al.*, 2009:131). The "Signal to Noise Ratio"(SNR) of the final signal is determined by the SNR of the input signal and the noise figure of the pre-amplifier (Schwab *&* Washino, 1996:9). Therefore the gain must always be checked in order to prevent the damage of any equipment (Dougherty, 1999:16).

Pads, usually found on pre-amps, are used to bring the instrument level down to mic level, as well as to reduce the amplitude of an incoming signal, serving as protection to an overload (Britton *et al.*, 1992:1304; Britton *et al.*, 1992:1304). Therefore, the pad is an attenuator, usually 10 to 20 dB (Smith, 1987:5). The pad acts as a downward extension of the gain control (Le *et al.*, 2010:1). It reduces the level of a loud input signal so that the gain can handle it without clipping (Menasché, 2002:18).

Filters not only reduce the high frequency noise, but by adding a pre-amp the noise in the filtering is minimized compared to the signal (Ho *et al.*, 2004:354). The pre-amp can act as a simple buffer between the source and the filtering equipment (Corey, 2010:33).

Polarity, explained by McCarthy (2010:376), is a directional indicator which is frequency-independent. In terms of polarity[2], by the input section, there will frequently be a polarity switch (Reese *et al.*, 2009:69). This is a mechanical switch that switches around the wires coming from pins two and three of the XLR input connector. When a sound source is picked up by more than one microphone, switching the polarity of one of the microphones can often fix the noise resulting from phase cancellation of certain frequencies (Alten, 1990:57).

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1 Patch bays are often set up near the mixing desk in order for the engineer to connect the equipment in different orders for each project, using short patch cables (White, 2012:53).

2 When referring to positive polarity, McCarthy (2010:376) explains that the input and output signals "track together in the same direction". This means that a positive waveform at the input, will create a positive waveform at the output. When these parameters are reversed, this signifies "Reverse" polarity (McCarthy, 2010:376).

6.2.9 Gain

'Signal to noise' ratio compares the level of a desired signal (music) to the level of background noise (Smith, 2011:15). The higher the ratio, the less obtrusive the background noise is. Therefore a healthy 'signal to noise' ratio (Wolfe & Godsill, 2000:821) needs to be higher than 1:1.

The noise floor is the measurement of a signal created from the total of all noise sources and unwanted signals within a measurement system, where noise is defined as any signal other than the one being monitored (Fielder, 1987:3; Moorer, 1999:2). The noise floor limits the smallest measurement that can be taken with certainty, since any measured amplitude must be no less than the noise floor (Frey, 1994:205; Dougherty, 1999:16).

Clipping consoles are usually equipped with a light that indicates when a signal is clipping, which results in distortion (West, 2000:924). This happens when the input level is overloaded and simply needs to be lowered in gain to prevent clipping (Zager, 2006:245).

Remember to reference what gain strength is being used, for example: -18/20 dBFS, to help with future recordings (Franz, 2004:12).

6.2.10 Control Room

Between the control room (where the recording crew resides) and the studio (where the artists are), effective communication is of utmost importance. Talk-back in this case, is the intercom system used in audio production studio control rooms (Kealy, 1982:114; Putnam, 1960:112). It enables communication between the booth and control room (Driedger *et al.*, 2005:15). The engineer in the control room can hear the artist through speakers when the artist speaks into the microphones (Newell, 2008:287). Talk-back systems come from a simple microphone that is built into the audio mixer, which enables the artist in the booth to hear the engineer through their earphones (Eargle, 1996:380; Putnam, 1960:115). Talk-back is vital to check before the artist arrives to save time and improve communication throughout the recording (Harrison, 2000:3).

It is also important to have complete control over the monitor levels in all situations and at all times (Kealy, 1982:112). The engineer has to establish a comfortable listening level in the control room (Putnam, 1960:115). When more tracks are added, the monitor level will rise accordingly, which may result in adjusting the volume to a reasonable sound level (Kefauver, 2001:533).

6.2.11 Backup Recorders

Backup recorders are a necessity to have in studio as well as at location recordings at all times (Nunes, 2013:12; Patton, 2010:22). The power supply needs to be able to handle hours of continuous operation, preferably with batteries in case there is a power out (Miyara *et al.*, 2010:2). It should also have an added option to be operated via USB bus power or an AC adapter (Verrier, 1999:90; Hirade & Ohtani, 2006:16). In the event of battery failure or accidental power loss, it is important to ensure that the recordings will not be lost (Patton, 2010:33). A data recovery function is often featured on these devices to automatically restore the data the next time the recorder is powered on (Hirade & Ohtani, 2006:16).

When devices are interconnected, they must be checked to see whether the clocks are synchronised (Loy, 2006:11). Clocks are often self synchronised, but need to be checked as the recorder often synchronises its clock to the mic pre-amp and the Digital-to-Analogue (D/A) converter will then synchronise with the recorder output (Nichols, 2013:97; Hirade & Ohtani, 2006:17). But the data out of the recorder could be out of sync with the data coming in due to delays, resulting in problems when monitoring the output of the D/A converter while recording (Loy, 2006:28; Ueno *et al.*, 1989:146). If the word clock inputs are available, it is a better solution to choose one device as the word clock master for the other devices (Verrier, 1999:90).

Even though it is a backup recorder, the amount of disc space needs to be checked to ensure enough space is available in the unlikely event that the recorder needs to be used (Coder, 2009:11; Dwyer *et al.*, 2003:13).

The In/Out section of the mixer is often used to tell each track where to search for incoming audio signals (inputs), and where to send the audio signals to (outputs) (Thompson, 2005:8). The In/Out section shows that the track is receiving audio from external channels (Verrier, 1999:90; Hirade & Ohtani, 2006:17). It also allows one to select various input sources such as external inputs ('Ext. In'), other tracks, or signals from applications (Loy, 2006:86). From here, one can check and verify the routing of the backup recorder (Thompson, 2005:10).

6.2.12 Start and Restart of Session

If each track has a unique input, the tracks can be armed individually or collectively (Shimonski & Basile, 2009:126). Ensure that all the necessary tracks are armed before pressing the record button. A track has to be armed in order to record on it (Campbell, 2013:62).

Ensure that there is a signal present on all of the necessary channels (Vaseghi, 2008:2). If there is no signal, there will be no recording on that channel (Loy, 2006:91).

To check whether the noise is absent, it is advised to do a test recording and listen for anything that could possibly stand out as noise (Loy, 2006:33). This could be a chair squeaking, the floor creaking, a hum from the lights or aircon, rustles from clothing or jewellery that the artist may be wearing, shoe shuffles if the artist moves while playing, clicks or any vibrating when low notes are played (Corey, 2010:108).

6.2.13 After First Pass

Always check the disk allocation, as every time a new audio track is created, the track needs to record to a hard drive (Arataki *et al.*, 1993:7; Van Ryzin, 2002:9). Ensure that the correct hard drive has been chosen to record to (Heo, 2006:20). It is important to never record to the system drive, but rather to a secondary drive not used by the operating system for system tasks (Holland, 2004:4).

Ensure that the playlists are verified (Van Ryzin, 2002:9). Each track can have more than one playlist (Cook, 2013:28). These playlists often help to keep track of takes by creating a new playlist for each take, though a take sheet should also be at hand (Burns, 2010:27). The playlists can also store or hide regions that one might want to refer back to (Albanese, 2008:30).

It is important to verify the clip numbers, as audio tracks have audio clips and events that have specific locations on the time-line of the recording (Machida *et al.*, 1985:7; Arataki *et al.*, 1993:11). Because the tracks are sample-based, the audio clips are correlated to specific sample locations (Loy, 2006:526). The material on these tracks keeps a constant fixed position on the track, even if the tempo or metre change in the session (Patton, 2010:30).

Ensure that all the tracks were recorded before moving on, as it is much harder to go back and record a track that was forgotten, a few days later (Van Ryzin, 2002:10; Heo, 2006:20).

6.2.14 End of Session

Figure out where to set up an Auto Backup option (Menasché, 2002:9). If this is active, a copy of the session will be saved at the interval specified. Also specify how many backup copies must be kept at a time (Wyatt & Amyes, 2013:145). These backup copies will be kept in a dedicated folder inside the Session folder, often called Session Backups (Hagerman, 2013:19; Collins, 2004:45). Also be sure to frequently save a copy on another hard drive, as well as a hard drive that is kept off-site (Cook, 2013:51).

Session notes need to be updated as a means of documenting aspects of the recording, mixing and mastering process. This is done in order to easily refer back to the session notes to see what was done and when specific happenings occurred (Nichols, 2013:94).

6.3 The compiled Audio Production Checklist

Noise Reduction

- ☐ Notice "Recording in Progress"
- ☐ Remove unnecessary equipment
- ☐ Air-conditioner
- ☐ Traffic
- ☐ Lights
- ☐ Service instruments
- ☐ 'Signal to Noise' ratio

Artist Comfort

- ☐ Welcome
- ☐ Drinks/snacks
- ☐ Music stand
- ☐ Seating
- ☐ Lights
- ☐ Comfortable environment
- ☐ Good headphone mix

Documents

- ☐ Sheet music
- ☐ Track sheet
- ☐ Recording log
- ☐ Take sheet
- ☐ Work order form
- ☐ Patch sheets
- ☐ Session notes
- ☐ Performance release

Computer

- ☐ Power saving mode off
- ☐ System sounds off
- ☐ Date
- ☐ Time

Local Area Network

- ☐ High-speed routers
- ☐ Network hubs
- ☐ Physical Network Cables
- ☐ Interconnections to third party networks
- ☐ Interactions to the World Wide Web and Internet connectivity
- ☐ Audio and video content servers in support of all DAW systems and mixing consoles.

Digital Audio Workstation (DAW)

- ☐ Patch bay
- ☐ Set Auto Backups
- ☐ Disc Allocation
- ☐ Disc Space
- ☐ Bit Depth
- ☐ Sample Rate

DAW Session

- ☐ TC layout
- ☐ Duplicate inputs
- ☐ Channel names
- ☐ Tracks

Microphone Placement

- ☐ Balancing
- ☐ Correct technique used
- ☐ Bleed
- ☐ Stands
- ☐ Cables
- ☐ Mechanical noise transfer
- ☐ Microphone level
- ☐ Safety

Pre-amplifiers

- ☐ Line level
- ☐ Gain
- ☐ Pads
- ☐ Filters
- ☐ Polarity

Gain

- ☐ Healthy 'signal to noise' ratio
- ☐ Noise floor
- ☐ Clipping
- ☐ Reference (-18/20 dBFS)

Control Room

- ☐ Talk-back
- ☐ Monitor Levels

Backup Recorders

- ☐ Power supply
- ☐ Clock Sync
- ☐ Disc Space
- ☐ Verify Routing

Start and Restart of Session

- ☐ All Tracks armed
- ☐ Signal present - all channels
- ☐ Noise absent

After First Pass

- ☐ Check Disk Allocation
- ☐ Verify playlists
- ☐ Verify Clip Numbers
- ☐ All tracks were recorded

End of Session

- ☐ Make backups
- ☐ Move backups off-site
- ☐ Update Session Notes
- ☐ Time Log
- ☐ Studio Log

CHAPTER 7

Data Capturing

Data analysis refers to the process in which the results are categorized into patterns which will enable the data to be explained based on the data attained from the participants (Berg & Lune, 2004:339). This is in order to clarify the phenomenon being researched and to identify common themes. This stage is essential, as it may predict the accuracy of the results (Maree, 2007:101).

The common themes have been identified, summarised and organised as follows, in a way that assists the elaboration on the main topic.

7.1 Data Collection and Classification

As the questions were answered by each participant, their yes/no answers were captured in tally tables as seen below. This was done to organise the data into smaller systematic units (Creswell, 1998:377). In order to analyse the data, the material gathered was converted into both pie charts and column charts in order to visually perceive the data most accurately.

Question	Tally Yes	Total	Tally No	Total
Do you think this checklist is suitable for the audio production process?	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ||	42	𝍸 𝍸 𝍸 𝍸 𝍸 |||	28

Figure 7.1: A Tally Table illustrating the answers given by the participants for Question 1

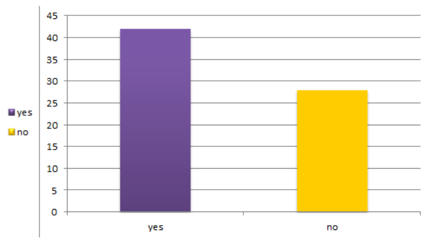

Figure 7.2: Do you think this checklist is suitable for the audio production process?

As seen in figure 7.1 and 7.2 above, the majority of the participants expressed that the Audio Production Checklist is in fact suitable for the audio production process.

Question	Tally Yes	Total	Tally No	Total
Would the checklist structure a recording?	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 |	61	卌 ||||	9

Figure 7.3: A Tally Table illustrating the answers given by the participants for Question 2

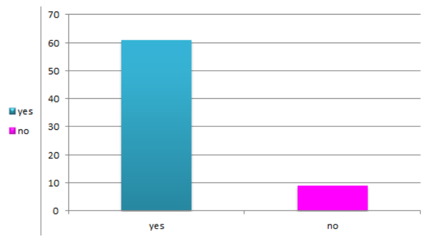

Figure 7.4: Would the checklist structure a recording?

Figure 7.3 and 7.4 reflect that the majority of the participants believe the Audio Production Checklist will in fact structure a recording.

Question	Tally Yes	Total	Tally No	Total
Would the checklist be better used simply as a guideline to follow?	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 |	66	||||	4

Figure 7.5: A Tally Table illustrating the answers given by the Participants for Question 3

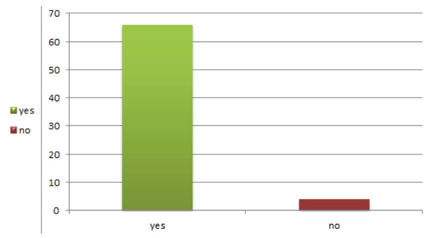

Figure 7.6: Would the checklist be better used simply as a guideline to follow?

Figure 7.5 and 7.6 indicate that the majority of the participants state that the Audio Production Checklist would be better used simply as a guideline to follow.

Question	Tally Yes	Total	Tally No	Total
Would the studio feel more organized with the use of the checklist?	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 III	63	𝍸 II	7

Figure 7.7: A Tally Table Illustrating the answers given by the Participants for Question 4

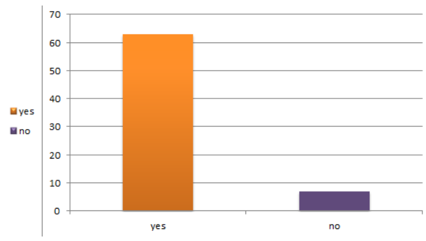

Figure 7.8: Would the studio feel more organised with the use of the checklist?

As regards figure 7.7 and 7.8, the majority of the participants feel that the studio would be more organised with the use of the Audio Production Checklist.

7.2 Synthesis

According to Major & Savin-Baden (2010:108), the purpose of the synthesis is to make sense of the findings that have recurred across a particular data set in order to develop a comprehensive picture of the findings. Therefore, the synthesis creates an interpretation of the findings for the reader (Creswell, 1998:377).

1. Do you think this checklist is suitable for the audio production process?

   Although the majority of the participants expressed that the Audio Production Checklist is in fact suitable for the audio production process, participants pointed out that certain sections of the checklist would apply more to the process before and during the building and preparation process of a studio or to a live recording situation. For example: air-con, fresh air ducting and lights are chosen before building a studio in order to be as silent as possible, though studios often have bright lights for set-up purposes that are noisy, and dimmers for the recording session. The lights still need to be checked in order to make sure the correct lights are switched off.

Also, participants state that no recording is the same, and that the checklist may need to be adjusted for each set-up according to personal preference.

2. Would the checklist structure a recording?

   Participants feel that the checklist would help to avoid certain issues and take care of others, and also helps the studio to be more organised. They believe it saves time, effort and generally puts everyone at ease. Therefore, the majority of the participants believe the Audio Production Checklist will in fact structure a recording.

3. Would the checklist be better used simply as a guideline to follow?

   If using the checklist simply as a guideline, participants believe it becomes second nature, although having it printed out, laminated and keeping it close by helps, as it is always easy to forget something important. The participants who responded with "no" feel that the checklist should be used rigorously, especially in bigger studios with multiple recording engineers active.

   The participants state that it is vital to know the process so well that one becomes adaptable within the process, as no two productions are the same and artists can sometimes require improvisation to get the best results. The participants also feel that there might not be enough time to work through the whole checklist; therefore, the majority state that the Audio Production Checklist would be better used simply as a guideline to follow, as it often comes down to personal preference.

4. Would the studio feel more organized with the use of the checklist?

   The majority of the participants feel that the studio would be more organised with the use of the Audio Production Checklist as it will help structure the process, though participants felt that keeping the sound engineers adherent to the checklist may be a challenge.

   Participants explained that the checklist addresses a very important list of things that make up an effective recording. Although it will take some effort to keep the studio running accordingly, the checklist serves as an effective production process and helps one realise what is often overlooked.

7.2.1 Summary

Most of what is needed for an audio production studio to run successfully is included in the audio production checklist. Although the checklist has particular items that have more relevance to the set-up of the studio than to the audio production process, these items still need to be checked on a regular basis in order to ensure that everything is still in good working condition. It may, however, dilute the general usefulness of the checklist.

Another challenge that may be faced, as far as filling in basic documentation such as a log or track sheet, is that time could make the filling in of documents a challenge. As mentioned in previous chapters, adding a checklist that attempts to be broadly comprehensive rather than succinct would be a hindrance. Thus the majority of the participants stated that the checklist would be better used simply as a guideline to follow, which is a logical option as there are seldom life threatening situations in an audio production studio.

Research has also shown how this checklist can benefit interns in the studio. Keeping the checklist at hand can help the interns familiarise themselves with the working of the studio and its contents. They can also use it as a reference in order to learn all the components of the studio inside and out.

Chapter 8

Conclusion

In an age of continuing internationalization, music is a global industry. Recording studios must be able to operate within this market. The aim of this study serves to critically investigate and research the content of the audio production process in an audio production studio. The content of seventy current participating studios throughout South Africa was scrutinized and comparisons were made by the use of questionnaires.

This thesis explores the checklists used in aviation, product manufacturing and medical fields, and to what extent they can be used to compile a checklist to be used in audio production studios, and might successfully be applied to audio engineering practice. It is found that the audio production checklist is in fact suitable for the audio production process: it will in fact structure a recording, and although the audio production checklist could serve better if used simply as a guideline to follow, studios would in fact be more organised with the use of the audio production checklist.

As mentioned in Chapter One, the overuse of a checklist can lead to checklist fatigue. Checklist fatigue occurs when the overwhelming number of available or required checklists becomes a hindrance rather than an aid. In audio production studios, the same aspect is considered.

Therefore, creating a clear and easy to use document that is adaptable to audio production studios is important. As long checklists increase the possibility of error caused by the accidental omission of checklist items, it is also important to limit the number of items listed. To encourage the use of a checklist in audio production studios, a simple to carry out structure will thus avoid checklist fatigue and result in a successful checklist.

In the recording studio, audio professionals are under the proverbial microscope; it is best to prepare properly in order to save time, money and frustration. In any project, unforeseen errors are often inevitable. This checklist helps to eliminate the unforeseen elements, enabling audio professionals to be prepared, avoiding known problematic issues so that artists may produce quality records, that are relevant and unique to stand out in the music market.

The audio production studio is meant to be a creative environment in which one feels comfortable, safe and excited to create music. If a checklist such as this one is not followed, human error is inevitable. As mentioned before, items on the checklist need to be in working order for a good recording to take place. If for some reason the checklist was not followed, it is essential to keep a calm and professional atmosphere while trying to remedy the situation, using the tools that are available.

It is evident that it is not merely technology that determines a recording, but rather the relationship between technology and the way in which it is used that determines its impact on every project.

Recommendations

The checklist can be manipulated slightly for different studios to get a precise working structure in place. While this study strictly focussed on a checklist for audio production studio recordings, further study may be continued to create a checklist for live recordings.

Appendices

Appendix A

Questionnaire

1. Do you think this checklist is suitable for the audio production process?

2. Would the checklist structure the recording?

3. Would the checklist be better used simply as a guideline to follow?

4. Would the studio feel more organised with the use of the checklist?

5. Additional comments

List of References

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