



Faculty of Cognitive Sciences and Human Development

**SECURE FIT AND PHYSICAL COMFORT OF SINGLE WIRED
EARPIECES FOR COMMUNICATION DEVICES IN FOOD AND
BEVERAGE SECTOR**

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(Cognitive Science)
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**SECURE FIT AND PHYSICAL COMFORT OF SINGLE WIRED EARPIECES FOR
COMMUNICATION DEVICES IN FOOD AND BEVERAGE SECTOR**

LEE KAH YEN

This project is submitted
in partial fulfilment of the requirements for a
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The project entitled 'Secure Fit and Physical Comfort of Single Wired Earpieces for Communication Devices in Food and Beverage Sector' was prepared by Lee Kah Yen and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours (Cognitive Science).

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ABSTRACT

Single wired in-ear earbud earpieces can facilitate communication among workers in food and beverage sector. If workers remove their headphones due to poor secure fit and discomfort, the communication effectiveness will decline and lower the work efficiency. The objective of this study is to identify the existing issue of secure fit and physical comfort of single wired in-ear earbud earpieces in food and beverage sector, do the comparison study of existing models of in-ear earbud earpieces and also document design recommendation of single wired in-ear earbud earpieces in terms of secure fit and physical comfort. A total of 16 participants were recruited for this study. Individuals were asked to experience with four models of in-ear earbud headphones while performing the tasks that simulated the job routines that take place in food and beverage sector. Semi structured interview and open-ended questions were used in this study. Content analysis was utilised to investigate the existing issues of single wired in-ear earbud earpieces, compare the different models of in-ear earbud headphones and list out design recommendation for future exploration. The results indicated that the overall physical comfort and secure fit of in-ear earbud headphones correlates with each other and there is a need to reconsider the current design of in-ear earbud headphones.

ABSTRAK

Telinga earphone berwayar tunggal boleh memudahkan komunikasi dalam kalangan pekerja dalam sektor makanan dan minuman. Sekiranya pekerja memadam fon kepala mereka disebabkan kurang tidak kukuh dan selesa, keberkesanan komunikasi akan merosot dan mengurangkan kecekapan kerja. Objektif kajian ini adalah untuk mengenalpasti masalah yang sedia ada bagi kekukuhan dan keselesaan earphone telinga berwayar tunggal dalam sektor makanan dan minuman, kajian perbandingan model telinga earbud yang sedia ada dan juga cadangan reka bentuk earphone telinga berwayar tunggal dari segi kekukuhan dan keselesaan fizikal. Sebanyak 16 peserta telah diambil untuk kajian ini. Individu diminta untuk mencuba empat model fon telinga semasa menjalankan tugas-tugas yang menyimulasikan rutin kerja yang berlaku dalam sektor makanan dan minuman. Kajian wawancara seminari dan soalan terbuka telah digunakan dalam kajian ini. Analisis kandungan telah digunakan untuk menyiasat isu-isu sedia ada yang terdapat dalam earphone earbud berwayar tunggal, membandingkan model yang berbeza dalam fon telinga earbud dan menyenaraikan cadangan rekabentuk untuk penerokaan masa depan. Hasilnya menunjukkan bahawa keselesaan fizikal dan fungsian keseluruhan fon telinga earbud berkorelasi antara satu sama lain dan terdapat keperluan untuk menimbang semula reka bentuk semasa dalam fon telinga earbud.

CHAPTER ONE

INTRODUCTION

Background of Study

The demand and usage of sports and fitness headphones are growing in popularity in the markets especially within the North America and Western Europe region. Consumers are spending more to purchase headphones which in other words users' expectations are getting higher mainly appetite for more additional features that can increase user experience (Savov, 2016). Wearable headphones are widely used by different age group as these devices provide communication and entertainment. On top of that, headphones are not only deployed for entertainment and sports purposes, they are also widely used in the workplace settings. The type of headphones that are involved in the workplace takes the nature of work into account.

Effective communication is important in food and beverage sector. A limitation in either receiving or expressing information can restrict participation and productivity at work. Single wired earpieces and walkie talkie are used as communication devices to coordinate staff seamlessly, collaborate productively and respond rapidly to orders and groups. Existing headphones in the market exhibit varied and unique design that can be possibly picked up to the single wired earpieces that are deployed in food and beverage sector as a supplement in design recommendation. Much more information of specification of shape design of one-sided wired earpieces are required to fulfil functional requirement of consumers from food and beverage sector. It is recognized that customer requirements and opinions are the principal factors for product development and achieving success in the market. Key issues for design include identification of the user groups' requirements and bodily dimensions. For external ear products such as wired earpieces and Bluetooth communication devices, comfort and secure fit are leading issues that caused loads of headphones being rejected at the user testing stage (Dysart, 2017).

Previous studies reported that there was negligence in designing earpieces which did not follow the ear profiles of consumers in different regions. There are a lot of different design of headphones with different standardization available in the market. More specialization is needed to cater for food and beverage sector users. This study examines the design concern of single wired earpieces for industry in the aspect of secure fit and comfort to result in better-quality products. Ear-related products have great potential to support several application domains ranging from safety critical, hospitality to food and beverage. Yet, the problem space is wide and design space still has area that has not been fully explored (Suhonen, Müller, Rantala, & Väänänen-vainiomattila, 2012).

Existing headphones with unique design in the market. There are multitude of headphone configurations that can be divided into categories such as over ear, on-ear, earbud and in-ear. This study examines the design of canal type earpieces that are deployed in the industry that will be connected with walkie talkie, hence the form factor of headphones that will be reviewed exclude the over ear type headphones as this type of headphones have huge earpads and earcups.

In-ear headphones. There are two types of in-ear headphones which are earbud headphones and in-ear-canal headphones. For earbud headphones as shown in Figure 1, they are small headphones that rest on the concha bowl of ear. This type of headphone is so called conventional earbuds create loose seal and provide low isolation in noisy environments. This earbud headphone provides situational awareness which makes it well suited for exercise, sports and active application. Many users are facing trouble to achieve the best comfort and secure fit due to the nature of earbuds which one size fits all (Johnston, 2018). These type of earbud headphones may not fit securely on the ear and fall out frequently which some of the headphones are paired with accessories like wings or loops to tuck under the ear ridges. Nowadays, it is not common to see the purely earbud type headphone in the market, there are

only a few manufactures that are producing this type of headphones such as Apple and Sennheiser as shown in Figure 2. The rest are usually canalphones with adopted earbud style housing.

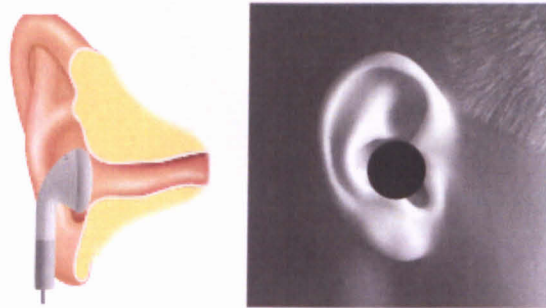


Figure 1. Earbud headphone fitting in inner bowl of ear (“Earphone Fit Guide”, 2013).



Figure 2. Existing earbud headphones in the market (“Earphone Fit Guide”, 2013).

As opposed to earbud headphones, in-ear-canal headphones as shown in Figure 3 and Figure 5 which also known as canalphones are inserted into ear canal. It is smallest type of all headphone types which it seals in ear with small tip inserted into ear canal. This tends to provide higher isolation than earbud headphones which little sound leakage can be experienced. The performance of in-ear-canal headphones highly relies on the ear tips to determine the comfort and secure fit. Comfort can be an issue as ear canal and surrounding of the ear canal is very sensitive. Ear tips are the contact interface between headphone and ear canal. There are multiple sizes and types of ear tips such as eartip with single flange, bi-flange and triple flange as shown in Figure 4. In-ear canal headphones often feature with different ear cushion materials such as silicone, rubber and memory foam to achieve

comfortable fit. Some ear tips are shaped to lock into the concha and have a protrusion that extends further into the ear canal (Sean, 2018).

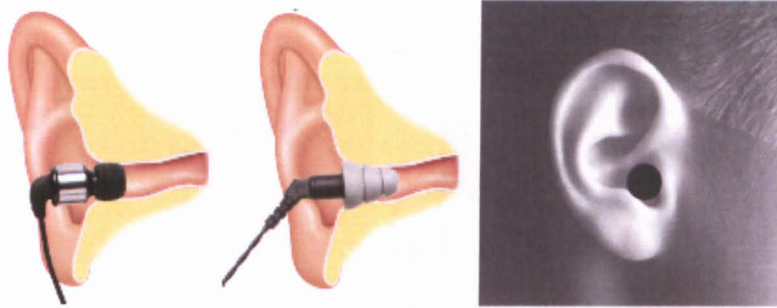


Figure 3. In-ear-canal phones fitting in ear canal (“Earphone Fit Guide”, 2013).



Figure 4. Ear tips with single flange, bi-flange and triple flange (“Earphone Fit Guide”, 2013).



Figure 5. Existing in-ear-canal headphones in the market (“Earphone Fit Guide”, 2013).

On-ear headphones. On-ear headphones which also known as supra aural headphones rests directly on the ear as shown in Figure 6. The on-ear headphones do not have earcups, instead with flat surface that is placed alongside the ear as shown in Figure 7. It allows more open and environmental sound as it does not close off the surroundings like the over ear type headphones do. Noise isolation is non-existing in this type of headphones and

they are light in weight (Flynt, 2018). In this study, the design of on-ear headphones such as huge form pad and leather pad are excluded due to the size that are not well suited in the industry usage.

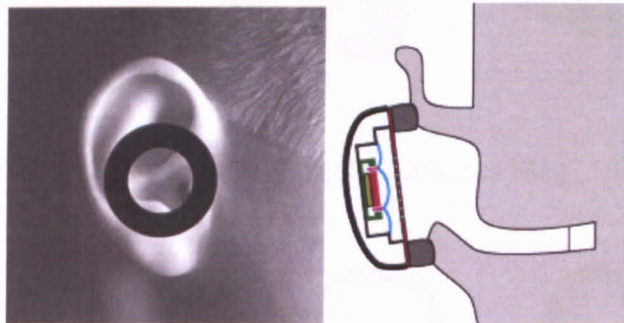


Figure 6. On-ear headphones sitting on inner bowl of ear (“Earphone Fit Guide”, 2013).



Figure 7. Existing on-ear headphones in the market (“Earphone Fit Guide”, 2013).

Headphones with additional accessories. In order to provide better user wearing experience, a lot of the companies keep producing different type of attachments on headphones. For an instance, ear tips as shown in Figure 8 with flexible structure that can extend up under the fold covering the cavity above ear canal. Besides that, some of the headphones with the over the ear features as shown in Figure 9 that have ear hooks that loop over the ear that will prevent the headphones from falling.



Figure 8. Existing ear fins (“Headphones Mag”, 2014).



Figure 9. Existing design of ear hooks (“Headphones Mag”, 2014).

Connectivity of headphones. Headphones can be divided into both wired and wireless devices. For an instance, mobility during work and duration of wearing are the key determiners that required the headphones to have certain features, for example the features like wired earpieces are highly utilised as time operation is essential that users have to stay connected which the wired features enable to supply power via cable and can operate for long duration (Lavery, 2017).

Existing headphones with unique design in the market. Table 1 shows headphones with design outlook for varied usage in the market. Figure 10 shows the sports and fitness headphones with both wired and wireless type while Figure 11 shows the music and entertainment headphones with wired and wireless type. The wireless type which is also known as headphones that are not able to connect with the audio jack.

Table 1

Existing headphones in the market

Product Outlook	Connectivity type	Application
In-ear canal headphone	Wired	Sports and fitness
In-ear earbud headphone	Bluetooth	
In-ear canal headphone	Wired	Music and Entertainment
In-ear earbud headphone	Bluetooth	



Figure 10. Existing sports and fitness headphones (“Headphones Mag”, 2014).



Figure 11. Existing music and entertainment headphones (“Headphones Mag”, 2014).

Structure of outer ear. The structure of outer ear can be divided into three main parts which are concha, pinna and external auditory canal. Shape of the outer ear can be beneficial to the canal type headphone design parts namely earphone head, ear tip, ear band and hook (Lee et al., 2016).

Anthropometric study of ear. Anthropometric data refers to measurement of human body dimensions. It is essential in headphone design as it allows specific and technical dimensions to be met in order to fulfil the physical needs of consumers. In the existing

research, it is found that the anatomical landmarks of outer ear such as tragus, antitragus, cavum concha and helical eadix will directly impact the comfort of wearing earbud headphones. Efforts have been made for the ergonomics design of in-ear products, a set of earbud size dimension in table 2 was proposed based on the normal distributions of ear hole length for females and males in Figure 12 (Ferguson, Greene, Repetti, Lewis, & Behdad, 2015).

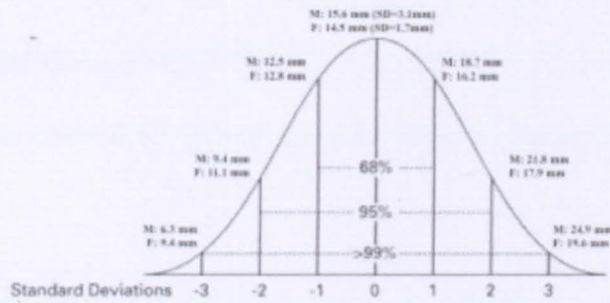


Figure 12. Normal distribution of ear-hole length for males and females. Adapted from “Combining Anthropometric Data and Consumer Review Content to Inform Design for Human Variability,” by T., Ferguson, M., Greene, F., Repetti, K., Lewis, & S., Behdad, 2015. *Volume 2B: 41st Design Automation Conference*.

Table 2

Dimension of earbud size from existing study

Earbud size	Earbud length (mm)	Earbud diameter (mm)
Small	10.25	5
Medium	15.00	6
Large	19.00	7

Note. Adapted from “Combining Anthropometric Data and Consumer Review Content to Inform Design for Human Variability,” by T., Ferguson, M., Greene, F., Repetti, K., Lewis, & S., Behdad, 2015. *Volume 2B: 41st Design Automation Conference.*

Besides that, the axis of the ear is essential to consider when designing in-ear products. One of the studies found that the long axis of the ear is approximately 20 degrees from vertical, hence angled earbud that is included will help to prevent earbud from falling out (Ferguson et al., 2015). It was also found that centre of concha is important for the reference point in headphone design which it can be applied to determine the size and shape of headphone components namely, earphone-head, ear hook and ear band as shown in table 3.

Table 3

Dimension of earphone head size from existing study

Earphone head size	Earphone head diameter (mm)	Coverage range (mm)
Small	14.6	13.4 – 15.7
Medium	16.9	15.7 – 18.1
Big	19.2	18.1 – 20.4

Note. Adapted from “Combining Anthropometric Data and Consumer Review Content to Inform Design for Human Variability,” by T., Ferguson, M., Greene, F., Repetti, K., Lewis, & S., Behdad, 2015. *Volume 2B: 41st Design Automation Conference.*

Ear dimensions. A total of 11 ear dimensions were chosen for testing through a review of literatures and studies that did by experts. Figure 13 and Figure 14 indicate the measurement of selected ear dimensions. The anthropometric dimensions of ear in Figure 13 in an ascending numbering order from 1 to 7 includes concha length, ear breath, ear length, tragon, concha length below tragon, concha breath and ear tilting angle. While in Figure 14

with numbering of 7, 11, 17 and 18, the ear dimensions that were chosen to measure were ear protrusion, cavum concha length, cavum concha width and cavum concha depth. The chosen ear dimension for measurement was only restricted to the external region of ear, hence the cross view of ear such as ear breath, ear length, tragion and ear tilting angle was chosen to measure for demographic data purpose. While concha dimensions are chosen as it was determined that it poses relationships of being secure fit and physical comfort (Ferguson et al., 2015).

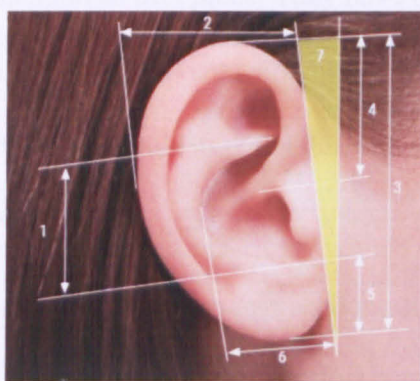


Figure 13. Selected ear dimensions.

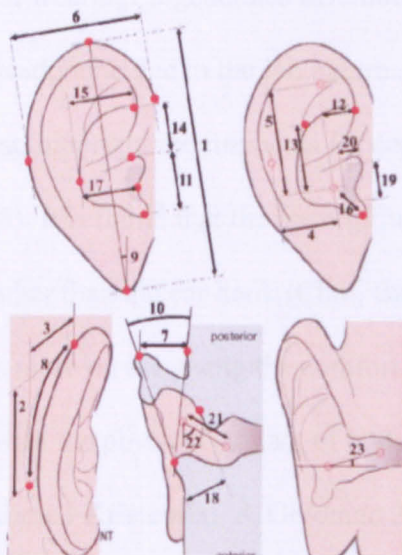


Figure 14. Selected ear dimensions for measurement. Adapted from “Anthropometric analysis of 3D ear scans of Koreans and Caucasians for ear product design,” by W., Lee, X., Yang, H., Jung, I., Bok, C., Kim, O., Kwon, & H., You, 2018. *Ergonomics*, 1-16.

Problem Statement

Secure fit design issue. One of the problems that users have been facing while wearing headphones is the earbuds tends to fall out especially huge movement is involved. The sense of fitness is one of the main factors that affect the overall satisfaction, hence, the elements of product design that affects the sense of fitness is essential to be further identified. Users experience poor fit in wearing the headphone causes communication effectiveness to be compromised. It is an annoying issue for those in-service line, retail, hospitality or any workplace that deem communication as first place. They have troubles in staying in touch especially when message is failed to be delivered smoothly due to the earbud is not staying well in the ear and require them to keep adjusting the position of earbud during shift (Stavrakos & Ahmed- Kristensen, 2012).

Comfort design issue. Comfort is taken into account in purchasing decision which has stressed the importance of comfort. A sense of comfort correlates with the user satisfaction in wearing headphone. Users experience pain in their ear due to the poor design of headphone after long hour of wearing. It generates irritation as users have to bear with the pain to continue wearing the headphone due to the job nature. From the review survey, it was found that comfort are the most important requirements for consumers for headphone products (Ferguson et al., 2015). It is found that the most influential factor of the ear-related products falls in the earplug rather than the ear hook (Choi, Ban, Choe, & Jung, 2015). Hence, there is a need to focus more on achieving the comfort. In addition, the industry of consumer products in related with the physical contact of body has recognized the need of striving comfort (Stavrakos, Ahmed-Kristensen, & Goldman 2015).

Lack of design criteria on single wired earpieces within food and beverage sector in the aspect of secure fit and physical comfort. There are too many design variations in terms of materials, size and degree angle of earbud. Reports on ergonomic related ear design