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Hearing Protection Devices: Usage at Work Predicts Usage at Play

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ABSTRACT

Use of hearing protection devices (HPDs) at work is widespread and well researched, but less is known about HPD usage in high-noise leisure activities. This study investigated 8,144

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Australians' HPD usage in leisure settings. An online survey asked questions about HPD usage at work and leisure, and examined whether age, gender, HPD usage at work, and tinnitus predicted HPD usage in leisure activities. Leisure-based HPD usage was most common during high-risk 'work-related' activities. Use of HPDs at work was the most significant predictor of leisure-based use, with workplace users up to 5 times more likely to use HPDs at leisure. Males were significantly more likely than females to use HPDs in 10/20 leisure activities, and those with tinnitus were more likely than those without to use HPDs in 8/20 activities. Older participants were more likely to use HPDs at nightclubs and concerts, but younger participants were more likely to use HPDs playing egames and musical instruments.

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INTRODUCTION

The prevention of hearing damage and noise-induced hearing loss (NIHL) arising from excessive noise exposure presents a unique challenge because high noise levels (> 85 dB L_{Aeq}) are commonplace in today's society, both at work and play. At work, the control of noise exposure is regulated by workplace legislation and standards, and employers are required to approach noise exposure as they would any other workplace hazard. To minimise risks associated with noise exposure, employers should first try to introduce permanent systemic changes, such as eliminating excessive noise, replacing noisy equipment, engineering physical barriers, or reorganising staff rosters to minimise time spent in noise. According to the hierarchy of hazard control[e.g., 1, 2], the use of personal protective equipment, such as earplugs or ear muffs (hearing protection devices, HPDs) should be regarded as a method of last resort because, despite the best intentions of management and staff, successful and universal HPD usage is difficult to achieve. Improper fitting, difficulties arising from ear canal shape and size, discomfort, lack of motivation, and perceived communication difficulties all play a role in reducing the effective use of HPDs in the workplace [3-5].

Despite the difficulties associated with HPDs, usage in the workplace is widespread - many employers opt for HPDs as the primary method of controlling noise exposure at work[6,7], and reviews suggest that use of HPDs as part of a hearing loss prevention program *does* reduce the risk of hearing loss[8, 9]. Recent advancements such as individual fit-testing of HPDs and technological improvements related to sound quality, active noise reduction and the communication capability should continue to improve HPD useability in the workplace and usage is also therefore likely to increase. [10-12].

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There is no doubt that, when fitted properly and worn consistently, HPDs offer significant noise attenuation, and perhaps this is why HPD usage is now increasingly being observed in a variety of noisy non-work (or leisure) settings. Earplugs are regularly worn by people riding motorcycles[13] and playing music [14, 15], while those using home power tools commonly opt for ear muffs. The few researchers who have investigated HPD usage in leisure settings have found that it is more widespread in activities such as shooting and motorsports than in music-related activities[16, 17], such as nightclubs and music concerts. Interestingly, while HPD usage at music venues is relatively uncommon in Australia and the US, much higher usage rates are observed in Scandinavian countries such as Sweden[18, 19].

Previous studies investigating HPD usage in non-work settings have focussed on specific groups such as adolescents, construction workers (at leisure), or concert-goers[16-21], and to our knowledge, there are no comprehensive studies of HPD usage in a full range of leisure settings across a wide age range. Thus the aim of this study was to describe the use of HPDs in a wide range of non-work (leisure) settings in a large sample of Australians. We hypothesised that usage of HPDs in the workplace would generalise to leisure settings and that those who had worn HPDs at work would be more likely than those who had not, to wear HPDs at home and other non-work environments. We also investigated whether factors such as age, gender, experience of tinnitus or self-perceived hearing status would predict the use of HPDs in leisure settings.

METHOD

Background

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Data for this study were collected in August 2012 from a large citizen science survey conducted during National Science Week, an annual government-funded event which celebrates and promotes science and technology. Originating in the biological sciences in the 1960s, 'citizen science' is an increasingly popular way of collecting large quantities of data from many different locations, while enabling participants to learn about the scientific topic and experience the scientific process [22]. Approval for the study was obtained from the Australian Hearing Human Research Ethics Committee.

The survey examined Australians' hearing health, and behaviours and beliefs relating to noise exposure, risk of hearing loss, and hearing health in general. Known as Sound Check Australia, the survey was administered online and comprised several different topic areas or 'modules' that examined different aspects of hearing health. The survey was conducted in conjunction with the Australian Broadcasting Commission (ABC)'s Science unit, which was responsible for development of the Sound Check Australia website and promotion of the survey, which was developed by the authors. The survey was open to anyone over the age of 15, and 9,904 people completed at least one module of the survey during the five weeks it was available online. The survey was promoted heavily in metropolitan and regional Australia, primarily through ABC radio and internet, and those who completed the survey were eligible to enter a competition to win concert tickets.

Participants

The results reported here are drawn from survey responses from 8,144 participants. The participants were aged 15 years and above and were drawn from all states and territories of

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Australia. Participants worked in a range of job types, with significant numbers of professionals, managers and students, and almost half the respondents were university educated. Demographic details of the participants are shown in Table 1, together with corresponding population statistics in brackets.

Survey Responses

In this paper, we report responses from seven survey items drawn from four modules. The items and response options are shown in Table 2. The first two questions simply asked about age and gender (items a & b). The survey items relating to self-reported hearing loss (item c) were reproduced from the Health Screening Inventory and scored using the method set out by the authors [27]. The items relating to tinnitus and noise exposure and HPD use at leisure and work (items d, e, f, g) were adapted from questions that had been used successfully in several previous online surveys administered by the research team [28,29,30]. The items relating to leisure noise (e & f) required respondents to provide information about their participation in 20 known highnoise leisure activities. For most of these activities, the average noise levels (L_{Aeq}) typically exceed 85 dB [31], but for others, such as home stereos, or e-games, the typical noise level can vary from relatively quiet to very loud, depending on the user.

Data Analysis

Survey responses from all 9,904 respondents were collected in a database, and participant responses to the questions of interest were extracted for analysis. Survey responses from 1,669 participants were excluded for one of two reasons: either a) participants had not completed the questions about HPD usage because they did not participate in any noisy leisure activities on at

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least a monthly basis and therefore were not shown these questions; or b) they had failed to complete the survey beyond the first two modules and therefore did not complete questions about HPD usage. A further 91 responses were excluded because the data were considered suspect, i.e., they contained inappropriate or spurious responses to one or more questions, resulting in a final dataset of 8,144 participants.

For each noisy leisure activity, descriptive statistics were used to characterise the use of HPDs during each activity. We then used ordinal logistic regression to investigate whether each of five predictor variables predicted the use of HPDs during each leisure activity. The five predictor variables were age, gender, degree of self-perceived hearing loss, experience of tinnitus, and whether the user had worn HPDs in at least one workplace.

RESULTS

HPD Usage in Noisy Leisure Activities

As shown in Figure 1, the noisy leisure activities during which HPD usage was most common were shooting (59.1%), and use of chainsaws (56.5%), power tools (50.5%), garden tools (42.1%). Just over one-quarter of participants who played in bands used HPDs at least some of the time. About 1 in 5 regular participants at festivals, motorsports events, music concerts, live gigs, and those who drove motorised vehicles also used HPDs. For all other activities, HPD usage was observed in less than 10% of participants.

Those who wore HPDs during noisy leisure activities tended to wear them regularly. For example, 84% of those who wore HPDs while shooting wore them at least 50% of the time. Similarly for chainsawing, 86% wore HPDs at least 50% of the time. For music-specific

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activities such as concerts, nightclubs, and playing instruments, the % of those who wore HPDs at least 50% of the time ranged from 44%-66% of wearers.

HPD Usage and Participation in Noisy Leisure Activities

HPD usage was considered in relation to the popularity of each noisy leisure activity, shown in Figure 2 in ascending order of popularity. The most popular leisure activities – attending pubs and listening to stereos – do not involve much use of HPDs, whereas using garden and power tools – the third and fourth most popular activities respectively – involve substantial HPD usage. In contrast, although HPD usage was high for shooting and chainsawing, participation in these activities was relatively uncommon in the study sample.

Ordinal Logistic Regression Analyses

To examine whether leisure-based HPD usage was associated with age, gender, tinnitus, selfperceived hearing loss or previous use of HPDs in the workplace, we conducted twenty ordinal logistic regression analyses, one for each noisy leisure activity. These analyses examined whether each of the five predictor variables predicted the use of HPDs during each leisure activity, when all the other predictor variables are held constant. There were two continuous predictor variables: age (15-100); and self-perceived hearing loss (HSI scores between 1 and 60, with higher 60 scores associated with greater severity of hearing loss). The other predictor variables were categorical: gender (male (1), female (0)); tinnitus (frequently/always (1) vs unsure/never/occasional/sometimes (0)); and HPD use in at least one workplace in lifetime (yes (1), no (0)). The dependent variable was use of HPDs during each noisy leisure activity

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participated in at least monthly. This was coded categorically as: yes, at least some of the time (1); no (0).

Table 3 shows the significant odds ratios obtained for each activity with music-related activities grouped together in the first half of the table. Note that listening to stereos, and attending sports and motorsports events are omitted from this table because these analyses did not yield any significant odds ratios.

An examination of the odds ratios revealed that use of HPDs at work was a significant predictor of HPD use in 14 of the 20 noisy leisure activities. For some activities – using power tools, playing in a band or orchestra, going to a festival or other live music event – the use of HPDs at work was associated with a 3-5 times greater use of HPDs at the leisure event.

Gender was associated with HPD usage for ten leisure activities: concerts, live gigs, pubs, parties, playing an instrument, playing in a band, driving a motorised vehicle, and using chainsaws, garden and power tools. In each case males were significantly more likely than females to use HPDs during these activities.

Tinnitus was significantly associated with HPD usage for eight leisure activities: concerts, live gigs, nightclubs, pubs, parties, playing in a band, using garden and power tools. That is, those with frequent or constant tinnitus were more likely than those with less experience of tinnitus to use HPDs while participating in these activities.

Age was also associated with HPD usage. A 10-year increase in age was associated with between 9% and 32% increase in the odds of HPD usage in nightclubs, concerts, fitness, driving a motorised vehicle, using chainsaws and garden tools. In contrast, a 10-year increase in age was

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associated with a 45% reduction in the odds of HPD usage in egames and an 18% reduction when playing instruments. This suggests that younger gamers and instrumentalists are more likely than their older counterparts to use HPDs when gaming or playing instruments.

For severity of self-perceived hearing loss (measured via HSI score), significant odds ratios were obtained for some leisure activities, but in all cases, the odds ratio was at or near 1 indicating no association between severity of self-perceived hearing loss and HPD usage during these leisure activities.

The relationship between workplace HPD usage and leisure-based HPD usage

In order to examine more closely the relationship between workplace HPD usage and leisurebased HPD usage, the percentage of participants wearing HPDs during noisy leisure activities was plotted for workplace HPD-wearers versus workplace non-HPD-wearers, as shown in Figure 3. The resulting figure shows that for all leisure activities (except those three in which HPD usage is least common), those who had worn HPDs at work were more likely to wear them during leisure activities.

Finally, we examined whether the type of workplace in which people had worn HPDs was related to the leisure environment in which they wore HPDs. To investigate this question, we considered HPD wearers in two noisy leisure activities (one music-related and one not musicrelated): shooting and nightclubs, and noted the workplaces in which they had previously worn HPDs. As shown in Figure 4, leisure shooters who wore HPDs while shooting had previously worn them in a wide range of industries and workplaces – some of which involve shooting (such as military and agriculture), and some which did not, such as music and construction. Similarly

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nightclubbers who wore HPDs while clubbing had experienced wearing them in a range of workplaces, some music-related, and some not.

DISCUSSION

This study shows that in a large Australia-wide sample HPD usage in high-risk noisy leisure activities was over 50% among regular shooters (59.1%), users of chainsaws (56.5%), and power tools (50.5%). HPD usage tended to be highest in 'work-related' noisy activities: using garden and power tools – two of the more common leisure activities in this sample. For other activities, HPD usage was less common, with usage under 10% for 10 of the 20 activities. Although this finding is of potential concern, it should be noted that at least in some cases, lower rates of HPD usage were associated with activities that emit lower noise levels, such as egames, where the typical noise level (L_{Aeq}) is around 65-75 dB, while for power tools, noise levels are more likely to be in the 85-95 dB range[25].

The pattern of HPD usage concurs with the few studies which report leisure-based HPD usage in other parts of the world. A study with an adolescent Swedish population found similar, albeit lower usage rates, with HPDs most commonly worn in shooting (38%), motorsports (36%), concerts (30%), playing in bands/orchestras (30%) and using lawnmowers (25%)[20]. Similarly, Hickson et al.'s 2007[**25**] study of Australian 13-19-year-olds reported that the activities with the highest HPD usage rates were: shooting (40%), noisy tools (34%), using lawn mowers (24%), motorsports (18%). Neitzel et al.[17] reported that among a cohort of young, mostly male, construction workers, HPD use in non-occupational activities was rare except for shooting, in which 45% of participants always wore HPDs.

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The regression analyses show that the most important factor behind HPD usage in noisy leisure activities was experience of HPDs in the workplace. In particular, when using power tools, playing in a band or orchestra, going to a festival or other live event, those who had worn HPDs in the workplace were 3-5 times more likely to wear HPDs at leisure. Interestingly, the type of workplace in which the HPD usage occurred was often different from the leisure activity in which people wore HPDs. For example, a chemical plant worker who wore earplugs at work also wore them while out at nightclubs, and a professional DJ who wore earplugs at work also wore HPDs when undertaking recreational shooting. Although we cannot claim that HPD usage at work is directly responsible for HPD usage at leisure, the results suggest a very strong association between the two, and it is likely that, at least for some people, familiarisation with HPDs at work acts as a trigger for using HPDs in other domains.

Older males were more likely than younger males to use HPDs when driving a motorised vehicle and when using chainsaws and garden tools, whereas males of all ages were more likely than females to wear HPDs at live gigs, pubs, parties, playing an instrument, playing in a band, and using power tools. This might reflect the fact that males are more exposed to HPDs at work because they tend to work in high-noise industries more than females. Overall, our data showed that 29.6% of males were exposed to noise at work vs 17.5% of females. The gender contrast in HPD usage is even more striking, with 52% of males who worked in noise reporting HPD usage at work whereas only 21% of women who worked in noise wore HPD at work. These results support previous findings that show a greater propensity for males to use HPDs[21]. However, other studies find no link between gender and HPD use[16], and yet others suggest females are more likely than males to use HPDs, at least at pop concerts[18].

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Age played a significant role in HPD use in nightclubs, concerts and fitness classes, suggesting that those who continue with these activities beyond their youth become 'older and wiser' and choose to protect their hearing while their younger counterparts remain either oblivious to the hearing risk or unwilling to mitigate it. This concurs with a Swedish study showing older Swedish adolescents were more likely than younger adolescents to wear HPDs at discotheques and concerts[16].

Perhaps not surprisingly, experience of tinnitus was a significant predictor factor for six musicrelated activities: concerts, live gigs, nightclubs, pubs, parties, playing in a band, as well as using garden and power tools, while self-perceived hearing loss had little effect on any activities. These results are consistent with other studies (albeit with younger participants) in which tinnitus was significantly associated with use of HPDs in leisure settings[16, 20, 32, 33].

Limitations

Although our sample was representative of the Australian population in terms of age, gender and geographic spread[23], many participants were highly educated, and by virtue of their participation in the Sound Check Australia survey, may have had greater awareness of, or interest in, hearing health than the general population. These factors may have influenced our results, although it is unclear exactly how. On the one hand, one might predict a more educated and aware population might wear HPDs more often[16]. On the other hand, the converse might be true: because higher education would be associated with less exposure to high-noise industrial workplaces and therefore less experience with HPDs, one might expect less HPD usage in this sample compared to the general population. In any case, the noted differences between the

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convenience sample studied here and the general population mean that one should not assume that the results reported here are generalizable to the Australian population.

This results of this study are drawn from survey questions which asked about participation in 'noisy' activities and use of HPDs. The survey items were designed to maximise face validity and minimise unnecessary wording or complexity, and there was little scope for the questions to be misinterpreted. However, it is acknowledged that the accuracy of the findings is dependent on the accuracy of participants' responses. Because the survey was online, it was not possible to validate responses against objective measures of behaviour, and it is possible that some respondents may have over- or under-represented their exposure to noise, use of HPDs, or experience of tinnitus. Because the survey questions were not formally evaluated for reliability or validity we cannot guarantee the veracity or repeatability of the results presented. However, the parallels between our results and previous research findings detailed above suggest that participants' self-reports were authentic, and that the findings are representative of HPD usage in the community from which the sample was drawn.

Implications

This study has important implications for the prevention of NIHL and promotion of hearing health in both occupational and leisure settings. Since those who wear HPDs at work are more likely to wear them in high-noise leisure situations, perhaps all noise-exposed workers should be familiarised with HPDs to encourage greater uptake of protective behaviours outside of work. Of course, this suggestion is made in the context of the hierarchy of hazard control, and while use of HPDs should always be considered a last resort in the workplace, it may be worthwhile to at least expose workers to the benefits of earplugs and earmuffs as a preventive measure. Innovative

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messages which explicitly link hearing health in the workplace and in leisure settings might help to encourage more widespread use of HPDs and thereby increase awareness of hearing health, and reduce the risk of NIHL (e.g., 'protect your hearing at work *and* play'; 'safety doesn't stop at the factory gate').

A different approach will be required for those who are not exposed to noise or HPDs at work. Perhaps hearing health promoters could focus on the fact that a significant number of individuals choose to wear HPDs in leisure settings, even where there is no external obligation to do so. This suggests that, despite any negative stereotypes that surround HPDs, many people regard them as both effective and desirable. A hearing loss prevention campaign which presents HPDs in a positive light in a wide range of settings could help to familiarise people who hitherto have not used HPDs, and help to normalise the use of HPDs in non-work settings.

The findings of this study suggest that in order to prevent NIHL we need to continue to concentrate hearing health efforts on both sides of the work/leisure divide. If, as this study indicates, there is a significant seepage effect, whereby knowledge of HPDs spreads from the workplace into the leisure domain, any attempt to familiarise employees with HPDs at work will have positive consequences beyond the workplace. Equally it is important that we continue to promote protective hearing behaviours in those who are not exposed to such information at work. Both approaches are needed if we are to increase noise awareness and protective hearing behaviours wherever we find ourselves at risk, whether at work or play.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Table 1. Survey items and response options shown in square brackets.

Module	Survey items and response options []
1. Demographics	a) Age [15-100] b) Gender [M; F]
2. Hearing Health	c) elf-reported hearing loss: 12 questions from the Hearing Screening Inventory [27]. Each item was scored 1-5 according to Coren & Hakstian [27] to generate a self-perceived hearing loss score between 1 and 60 with higher scores associated with greater severity of hearing loss. d) <i>Tinnitus is defined as any</i> <i>sound a person can hear internally that is not</i> <i>present externally. It may be heard as a</i> <i>buzzing, ringing, whistling, hissing or pulsing.</i> Have you ever experienced tinnitus? [Unsure; Never/Almost never; Occasionally; Sometimes; Frequently; Always/Almost always]
3. Recent Noise History	 e) When have you participated in the following leisure activities* (don't include activities you did as part of paid work)? [At least once in the past month; Not in the past month, but usually at least once a month; Not in the past month, but I have in my lifetime; Never] If participant selected: At least once in the past month or usually at least once a month, they were asked: f) Do you use hearing protection when participating in this activity? [No; Yes - less than 10% of the time; Yes - less than 50% of the time; Yes - more than 50% of the time; Yes - More than 90% of the time]
4. Work Noise History	For "each work environment in which you were exposed to loud noise (so you had to raise your voice to be heard) for at least three months", <i>respondents were asked:</i> g) Did you use hearing protection while in this work environment? [Yes; No].

* The "following leisure activities" were: nightclubs; pop/rock concerts; live music

performances (gigs) at small venues; other live music performances; music festivals; pubs with background noise; parties or dances with amplified music; play in a band with amplified music;

play in an orchestra/concert band; fitness class with amplified music; play a musical instrument; use a car/home stereo at loud volume; play electronic games at loud volume; live sports events; motor sports events; drive motorised vehicles; shooting; use garden power tools;

wood/metalwork power tools; chainsaw.

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Table 2 Percentage of respondents in each gender, age, location, education, and employment

category.

Gender	% of sample	Location	% of sample	
Male (49.8%)*	50.4	New South Wales +	37.3	
		Aust Capital Territory		
		(33.8%)*		
Female (50.2%)*	48.9	Victoria (24.8)*	21.3	
Unspecified	0.7	Queensland (20.1%)*	17.6	
Age		Western Australia	7.9	
		(10.8%)*		
15-24 (13.4%)*	29.1	South Australia	7.2	
		(7.3%)*		
25-34 (14.6)*	21.7	Tasmania (2.2%)*	5.4	
35-44 (13.9%)*	13.3	Northern Territory	1.0	
		(1.0%)*		
45-54 (13.3%)*	13.8	Unspecified	2.3	
55-64 (11.4%)*	13.7	Employment		
65-74 (8.1%)*	6.9	Manager/Professional	35.8	
		(22.3%)**		
75+(6.4%)*	1.4	Student (13.6%)***	21.4	
Education		Retired/not	17.6	
		working/home duties		
		(20.5%)***		
No formal	0.5	Technical/Trade	7.9	
schooling/some		(9.8%)**		
primary				
Some secondary	15.5	Clerical/Admin	7.3	
(26.9%)†		(9.7%)**		
Completed secondary	16.3	Labourer/Machine	3.4	
(20.4%)†		operator (10.9%)**		
Trade qualification	18.2	Community worker	3.2	
(27.8%)†		(6.2%)**		
University (24.7%)†	49.4	Sales (6.1%)**	3.1	
Unspecified	0.1	Unspecified	0.3	

Population figures were extracted from reports published by the Australian Bureau of

Statistics[23]*;[24]**;[25]***;[26]†

Table 3. Significant Odds Ratios for HPD Usage in 17 Noisy Leisure Activities. 95% confidence intervals are shown in brackets. # Odds ratios for age are expressed as a 10-year increase in age.

	Age#	Gender M – 1	Tinnitus Tinn	HSI Score	PHP at work
	1 gen		-1	hor beore	PHP - 1
Concert	1 19*(1 03-	1 6/** 1 17-	$15/1*105_{-}$		1 M = 1 1 85* 1 11_
Concert	1.19 (1.05-	2.28	2.26		3 10
Live gig	1.50)	1.20	1 91*** (1 5-		2 11***
Live gig		1.75)	$(1.5)^{-1}$ $(1.5)^{-1}$		(1.52-2.92)
Pub		(1-2)	2.45)		2 21***
1 00		(1-2.2)	(1.59-3.47)		(1 39 - 3 51)
Nightelub	1 24** (1 06-		2 23***		2 31** (1 38-
1 (Igineiuo	1.24 (1.00		$(1 \ 48 - 3 \ 34)$		3.88)
Party	1.15)	1 83* (1 16-	1 97** (1 24-		2 40** (1 4-
rarty		2 91)	3 13)		2.40 (1.4 4 11)
Instrument	0.82** 0.73-	3 23***	5.157		2 59***
mstrument	0.02 0.75	(2, 19-4, 76)			(1.64-4.10)
Play hand	0.757	3 56***	2 10***		3 60***
They build		(2, 29-5, 54)	(1.38-3.18)		(1.88-6.89)
Other live			(1.50 5.10)	1 04* (1 01-	3 63***
				1.07	(2.07-6.35)
Festival	-				4.63***
					(2.28-9.39)
Play orchestra					5.17***
2					(2.00-13.38)
Motor vehicle	1.24***	1.52* (1.04-			
	(1.12-1.38)	2.22)			
Chainsaw	1.18***	3.44***			1.94***
	(1.10-1.27)	(2.59-4.55)			(1.39-2.73)
Garden Tools	1.09***	2.08***	1.38***	0.98** (.97-1)	2.38***
	(1.04-1.14)	(1.77-2.45)	(1.17-1.64)		(1.94-2.91)
Shooting					2.41* (1.14-
C					5.08)
Power tools		2.64***	1.61***	0.99* (0.97-	3.14***
		(2.18-3.20)	(1.33-1.95)	1.00)	(2.50-3.95)
Fitness	1.32** 1.11-				
	1.57				
egame	0.55** (0.36-			1.06* (1.01-	
	0.86)			1.11)	

Levels of significance are shown as:

*** < .001,

** < .01,

* <.05.



Figure 1



Figure 2



Figure 3



Figure 4

²⁸ ACCEPTED MANUSCRIPT