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# **Comparing risk-taking and digit ratio (2D:4D) in offenders and non-offenders**

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## **Abstract**

Offenders differ from non-offenders in their propensity to engage in risk-taking behaviour. The ratio of the index and ring fingers (2D:4D), a proxy of prenatal testosterone exposure, has been linked to risk-taking behaviour. The present study compared risk-taking in 45 male offenders and 66 non-offenders using the Balloon Analogue Risk Task (BART). Furthermore, it sought to determine the relationship between their 2D:4D ratios and risk-taking behaviours. No significant differences were found between the two groups in their risk-taking behaviour and no significant correlations were found between 2D:4D and risk-taking in either group. These findings are discussed in relation to previous research, limitations of the current study and possible future research.

## **Ethical Declaration**

The present study was conducted in accordance with the ethical conditions and procedures outlined by the British Psychological Society. Ethical approval from the Ethics Committee in the Department of Psychology at the University of Plymouth was obtained prior to the study being conducted. The appropriate forms can be found in the appendices. Consent was obtained from the manager of the Friends On The Outside (FOTO) project to undertake the research with their clients and to use facilities within their project in order to do so.

## **Acknowledgements**

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## **Introduction**

The ever increasing prison population in England and Wales has been of rising concern over the years. England and Wales has a higher rate of incarceration than any other western European country with 155 people in every 100,000 of the population in prison (International Centre for Prison Studies, 2012). There are 132 prisons in England and Wales and the current prison population as of the 2<sup>nd</sup> March 2012 stands at 87, 787 with 83, 601 of these being male prisoners (Ministry of Justice, 2012). One issue that has raised high levels of concern in the prison service in England and Wales are the unreasonably high reoffending rates. A report from the Prison Reform Trust (2011) shows that 49% of adults that are released from prison reoffend within one year, which increases to 61% for those on short sentences of 12 months or less and for those who have previously had 10 or more custodial sentences the reoffending rate rises to a staggering 79%.

The increasingly high, predominantly male prison population has prompted many researchers to take a closer inspection of offenders and their behaviour. Many researchers have been interested in the link between offending and risk-taking behaviour. It is believed that offenders who have spent time in prison have done so because of their willingness to take risks by engaging in criminal activities and that offenders differ from non-offenders in terms of their risk-taking behaviour (Hanoch & Gummerum, 2010; Thornton, 1985). Committing a crime generally involves taking some sort of risk, as the outcome of a crime is often uncertain (Dahlbäck, 1990). In their general theory of crime, Gottfredson and Hirschi (1990) identified risk-taking as a major component of self-control and found that there was a relationship between criminal behaviour and poor self-control. The theory claimed that people who lack self-control tend to take more risks and are therefore more likely to engage in criminal acts.

Previous research in prison populations has shown that offenders are more likely to engage in activities that involve taking risks and have focused on areas of risk-taking concerning substance abuse, unsafe sex and gambling. Research by Fazel, Bains and Doll (2006) interviewed prisoners upon entering custody and found the rate of

substance abuse and dependence to be much higher than in the general population, especially with regards to female prisoners. A study involving Russian prisoners found evidence of HIV/AIDS risks in prisons, with only 17% of male inmates and none of the female inmates having reported ever using a condom whilst engaging in sex inside prison (Frost & Tchertkov, 2002). It was also found that 1% of the prisoners reported all three of the prison risk behaviours. These included sexual activity in prison, having a tattoo in prison and injecting a drug in prison. Templar, Kaiser and Siscoe (1993) studied inmates at a Nevada prison and found that 23% had a gambling problem and 26% were probable pathological gamblers. These studies demonstrate that offenders are risk takers in a number of different areas.

Another area in which offenders have been shown to take risks is within the financial domain. Research by Farago, Kiss and Boros (2008) studied the risk-taking behaviour of entrepreneurs and offenders in comparison to a control group of students in a bidding paradigm and found that the level of risk-taking in offenders was generally higher than both of the other groups. Offenders were found to take greater risks than both entrepreneurs and students in uncertain situations and also took greater risks in the losing situations than the winning situations. Similarly, Pachur, Hanoch and Gummerum (2010) found that offenders in a prison population were more likely to take risks when a loss situation was probable when asked to choose between hypothetical monetary risky options. Research by Block and Gerety (1995, as cited in Pachur et al., 2010) also reached similar conclusions in a study comparing the responses of prisoner and student responses to monetary risks. It found that prisoners were significantly more likely to take a risk when there was a possibility of a loss. These studies suggest that offenders show high levels of monetary risk-taking, especially when a loss rather than a gain is possible. Despite the many studies that have looked at the risk-taking behaviour of offenders, very few have looked at comparing them with non-offenders, therefore this study seeks to compare risk-taking in offenders and non-offenders.

The vast majority of research in this area has relied heavily upon the use of self-report instruments in order to measure risk-taking behaviour. Many studies have used these instruments to measure constructs relating to risk-taking, such as sensation seeking, venturesomeness and impulsivity; however reliance upon these measures have presented many limitations. Self-report instruments may be limited by the negative consequences that could possibly be perceived as a result of reporting certain risky behaviours and some people may be unable to provide an accurate account, as they may lack the ability to report their own risk-taking behaviour (Lejuez, Read, Kahler, Richards, Ramsey, Stuart, Strong & Brown, 2002). Many of the existing self-report measures also fail to capture the full nature of risk-taking as it is such a broad behaviour.

Other approaches to the assessment of risk-taking behaviour have included behavioural measures, such as the neuropsychological task developed by Bechara, Damasio, Damasio and Anderson (1994), that simulate real-life decision making, however a number of these tasks have also presented limitations. Many behavioural measures of risk-taking have been found to have poor convergent validity with regards to self-report instruments that measure constructs of risk-taking (White, Moffitt, Caspi, Bartusch, Needles & Stouthamer-Loeber, 1994).

To address the limitations of self-report instruments and other behavioural measures of risk-taking behaviour, the Balloon Analogue Risk Task (BART) was developed to provide a more comprehensive measure of risk-taking (Lejuez et al., 2002). The BART is a computerised task designed to measure actual risky behaviour and can be used as an alternative approach for assessing risk-taking behaviour. In this task there are a set number of trials. In each trial participants are presented with a simulated balloon from which they can accumulate money in a temporary bank by pressing a button to inflate it. Each balloon has an explosion threshold and can explode at any point, resulting in the loss of any money accumulated in the temporary bank. For each pump of the balloon that does not result in an explosion, participants are able to press a button that will transfer any money gained from that balloon in the temporary bank to a permanent bank. Once a balloon has exploded or money is collected, the participant moves onto the next trial. The BART is designed to correlate with scores on self-report instruments that relate to risk-taking constructs and to the occurrence of self-reported real-world risk behaviours (Lejuez et al., 2002).

The BART had been used in many studies to measure a range of risk-taking behaviours. Lejuez, Simmons, Aklin, Daughters and Dvir (2004) used the BART to determine the relationship between risk-taking and risky sexual behaviour in residents of substance use residential treatments programmes. They found that, as shown by performance on the BART, risk-taking propensity was related to risky sexual behaviour. The BART has also shown increased risk-taking in smokers compared to non-smokers (Lejuez, Aklin, Jones, Richards, Strong, Kahler & Read, 2003). Skeel, Neudecker, Pilarski and Pytlak (2007) found that participants BART score was significantly correlated with weekly alcohol consumption. Other research has used the BART to determine whether drug use has an effect on risk-taking. Risk-taking was assessed in individuals using different types of drugs to determine whether it was affected by the type of drug being used. The researchers found higher levels of risk-taking in crack cocaine users than heroin users (Bornovalova, Daughters, Hernandez, Richards & Lejuez, 2005).

Few previous studies have used the BART as a measure of risk-taking to compare offenders and non-offenders. This study will therefore use the BART as a measure of risk-taking behaviour in order to compare offenders and non-offenders. As previous research has shown that offenders have a tendency to engage in risky behaviours, it is predicted that offenders will show a greater level of risk-taking than non-offenders on their BART scores.

Studies have shown that men are more likely to engage in risky behaviour than women (Wang, Kruger & Wilke, 2009), which has gained the interest of many researchers into exploring the role that testosterone plays in risk-taking behaviour, particularly through the use of digit ratio. Digit ratio is the ratio of the length of the index finger to the ring finger (2D:4D). It has been suggested that 2D:4D ratio is affected by early exposure to androgens, such as testosterone, in the uterus and that 2D:4D is negatively correlated with prenatal testosterone levels (Manning, Scutt, Wilson & Lewis-Jones, 1998). It seems that early exposure to prenatal testosterone reduces the growth of the second digit in relation to other fingers and has important effects of brain organisation (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer and Manning, 2004). Digit ratio is a sexually dimorphic trait in humans, as low 2D:4D values, which relate to a shorter second digit relative to the fourth, are associated

with high levels of testosterone and is typical for males, whereas high 2D:4D values relating to a shorter fourth digit relative to the second, are associated with lower levels of testosterone and is typical for females (Manning et al., 1998; Manning, Bundred, Newton & Flanagan, 2003; Phelps, 1952). Research has shown that right hand 2D:4D is a better indicator of prenatal androgenisation than left hand 2D:4D (Hönekopp & Watson, 2010).

Several studies have provided evidence that 2D:4D can be used as a method for studying prenatal testosterone levels in humans. Lutchmaya et al., (2004) found that 2D:4D in the right hand correlated negatively with testosterone after obtaining testosterone levels from 29 fetuses and comparing them with 2D:4D ratios 2 years after birth. Other research has looked at the digit ratios of people affected by Congenital Adrenal Hyperplasia (CAH), a condition that causes excessive androgen production during gestation and compared them with normal controls (Brown, Hines, Fane & Breedlove, 2002). It found that people affected by CAH had a lower 2D:4D, which is consistent with the idea that high prenatal testosterone levels are reflected in low 2D:4D. Further evidence for a link between 2D:4D and prenatal testosterone found that males who had no sufficient exposure to prenatal testosterone due to a syndrome causing insensitivity to androgens had digit ratios that were similar to those that are typical of females (Berenbaum, Bryk, Nowak, Quigley & Moffat, 2009). Again, this finding is consistent with previous research that the 2D:4D ratio reflects prenatal testosterone levels and suggests that it can be used as valid research tool. It has become a popular means of researching the effects that prenatal androgen exposure has on humans, especially the effects that it has on their behavioural traits.

A vast amount of research has focused on the relationship between 2D:4D and human behavioural traits and there is evidence to suggest that the 2D:4D ratio, a marker of prenatal androgen exposure, could be related to risk-taking behaviour. This area has largely been researched in a financial context. Coates, Gurnell and Rustichini (2009) studied the digit ratios of male, high-frequency financial traders and those with low 2D:4D ratios were found to perform better than those with high 2D:4D ratios and a lower and more masculinised digit ratio indicated the traders' long-term profitability. This suggests that individuals with a low 2D:4D are likely to show more financial risk-taking. Similarly, Coates and Page (2009) found a negative correlation between the digit ratios and risk-taking levels of male high-frequency financial traders. Research by Dreber and Hoffman (2007, as cited in Coates & Page, 2009) also found support for this relationship in their study consisting of an ethnically homogeneous sample of men and women in Sweden, which found that lower 2D:4D was related to greater financial risk-taking. Stenstrom, Saad, Nepomuceno and Mendenhall (2011) used the domain-specific risk-taking propensity scale (Weber, Blais & Betz, 2002) to study the relationship between 2D:4D and risk-taking. The scale assesses risk-taking across five different domains, which include financial, social, recreational, health and ethical. Their study found that low 2D:4D indicated greater risk-taking in the financial, recreational and social domains, which is again consistent with the idea that 2D:4D could be related to risk-taking behaviour.

Whilst a large amount of the research linking digit ratio with risk-taking behaviour focuses on financial risk, other researchers have studied different areas of risk-taking in relation to digit ratio. Some research has identified a relationship between the 2D:4D ratio and personality traits that are closely linked to risk-taking, whilst other areas of research have looked at the relationship between 2D:4D and risk-taking

behaviour in activities such as driving. Fink, Neave, Laughton and Manning (2006) observed higher sensation seeking in men with lower 2D:4D ratios. Schwerdtfeger, Heims and Heer (2010) found that individuals with higher prenatal testosterone exposure had more self-reported traffic violations, showing that a lower 2D:4D ratio was inversely related to risk-taking behaviour. All of these studies support the idea that because 2D:4D is prenatally determined, the organisational effects of testosterone exposure can affect risk-taking behaviour.

Few of the previous studies linking digit ratio and risk-taking behaviour have measured risk-taking on a scale that shows a domain general level of risk-taking. Much of the research in this area has focused on specific areas or traits related to risk-taking, such as finance and sensation seeking, rather than viewing risk-taking as an overall behavioural trait. Self-report instruments have been widely used as a measure for risk-taking behaviour in a number of studies linking digit ratio and risk-taking, which, as already mentioned, can provide many limitations. It seems that offenders' risk-taking tendencies have been widely researched; however there appears to be no research that studies digit ratio and risk-taking behaviour in relation to offenders.

In light of the previous research, this study seeks to compare the risk-taking behaviour of male offenders and non-offenders through the use of the BART. It is hypothesised that offenders will show greater risk-taking on the BART in comparison to non-offenders, as it has previously been shown that offenders have greater risk-taking tendencies. Furthermore, it seeks to establish the relationship between digit ratio and risk-taking in both male offenders and non-offenders. It is hypothesised that digit ratio will be correlated with risk-taking on the BART for both offenders and non-offenders, but that a stronger correlation will be shown for offenders. This is because evidence suggests that 2D:4D is related to risk-taking behaviour; however offenders will be more likely to engage in risk-taking behaviour than non-offenders.

## **Method**

### **Participants**

The participants consist of 45 male offenders from the Friends On The Outside (FOTO) project who were within 16 weeks of their prison release. The offenders were between 21 and 58 years of age ( $M = 39.02$ ,  $SD = 8.57$ ). The foremost offence committed by offenders was theft and burglary (60%), whilst 56% had committed drug offences and 47% had committed a violent offence excluding murder and manslaughter. Offenders were compared with 66 non-offenders from the community, who were between 19 and 60 years of age ( $M = 32.77$ ,  $SD = 10.51$ ). An independent t-test revealed that offenders were significantly older than non-offenders,  $t(105) = -3.24$ ,  $p = .002$ . Offenders generally had a lower level of education in comparison to non-offenders. Out of the 45 offenders, 14 (31%) had no education at all, whereas only 2 (3%) of the non-offenders indicated having no education. The General Certificate of Secondary Education (GCSE) was stated as the highest educational attainment for 10 (22%) of the offenders and none reported having obtained A-levels; as opposed to 29 (45%) of the non-offenders having achieved GCSE's and 9 (14%) having obtained A-levels as their highest level of education. Similarly, offenders and non-offenders also differed in their employment status as only 3 (7%) of the offenders indicated that they were employed, compared with 29 (45%) of the non-offenders. Another area in which participants differed was their weekly income.

Twenty-four (41%) of the non-offenders reported a weekly income of less than £100, compared with 37 (82%) of the offenders. A similar number of non-offenders (14; 24%) and offenders (8; 18%) indicated a weekly income between £101 and £200, however 21 (36%) of the non-offenders and none of the offenders reported a weekly income of £200 and above.

### **Materials**

A computer with internet access was used in order to run the BART programme and a Hewlett Packard Scan-jet 4100C scanner was used to scan participants' hands. Digital Vernier Callipers were used to measure participants' digit lengths from a photocopy of their hand scans in order to compute their digit ratios. Gift vouchers were given as payment to offenders that took part in the study. This was in compliance with requests from the FOTO project not to give out cash payments to clients. Non-offenders were paid in cash for their involvement in the study. A debrief was also given to each participant at the end of the study to read and take away with them.

### **Design and Procedure**

A quasi-experimental design was used in order to carry out the study. The research was approved by both the FOTO project and the university ethics committee. Offenders were recruited via the FOTO project, where posters were placed around the building which contained information about the study and invited clients of the project to take part. Non-offenders were recruited from the local community. All those who wished to participate in the study were tested individually in a designated room either at the FOTO project (offenders) or at the university (non-offenders).

To begin the study all participants were given a brief and a consent form (Appendix A). All information contained in the brief was administered to participants both orally and in written form. The brief informed participants about the study, what they were required to do as a participant and that they were free to withdraw at any time. Participants were also reassured of their confidentiality throughout the study. Participants were informed that their name would only appear on their consent form to keep a record of who had participated in the study and they would each be assigned an individual participant number that would be recorded on their hand scans and any data obtained from them throughout the study. Each participant was asked to sign a consent form to show their compliance in taking part in the study.

Once participants had signed the consent form they were asked to fill out a short questionnaire regarding personal details such as their age, weekly income, employment status, highest attained level of education, number of previous convictions, the timing of their last conviction and the type of offence that it concerned (Appendix B). It was explained to participants that this was to ensure that the correct people were taking part in the study and to gain an overview of their background.

To examine risk-taking, participants completed the BART (Lejuez et al., 2002). Each participant was sat at a computer and the experimenter entered their individual participant number into the BART programme. Participants were presented with on-screen instructions for the BART, which were also explained orally by the experimenter. Once participants were confident that they understood the instructions, they were asked to click on the button marked 'Press here to begin' to



proceed with the task. Each participant was presented on the computer screen with a balloon. In order to pump up the balloon they could click on the button located underneath it labelled 'Press this button to pump up the balloon'. Each balloon in the task had a different threshold for explosion and could explode at any point from the first pump to enough pumps for the balloon to fill the entire computer screen. For every pump of the balloon, participants accumulated 0.5 pence in a temporary bank. Participants could stop pumping up the balloon at any point by clicking on a button located towards the left of the screen labelled 'Press to collect £££'. By clicking this button any money accumulated from that particular balloon was transferred from the temporary bank into a permanent bank, which appeared to the right of the screen labelled 'Total Earned' and displayed the overall amount earned for the whole task. Any money that had been earned on a previous trial was shown in a box below the total earned and was labelled 'Last Balloon'. If a balloon exploded whilst the participants were still pumping it up and prior to pressing the 'collect' button, then all money that was earned in the temporary bank for that trial was lost and a new trial would begin. Whilst money in the temporary bank was lost if a balloon exploded, it did not affect any money that the participant had earned in the permanent bank. All participants undertook 30 balloon trials in this task.

To examine 2D:4D digit ratio, measurements were taken by following the work of previous studies (Kemper & Schwerdtfeger, 2009; Manning, Trivers, Thornhill & Singh, 2000; Voracek, Manning & Dressler, 2007). An image of the participants' right hand was scanned. All participants were asked to place each hand on the scanner with their palms facing downwards, their fingers placed together and to remove any rings, especially those on the index or ring finger. This was to minimise any interference when taking measurements for each participant's digit ratio. To ensure that all hands were the same size in the scan, a preview was done before scanning and a box was drawn around each hand to ensure that they were all to the same scale. This would make measurements for the digit ratio more accurate. To measure the 2D:4D, two independent raters, who were blind to the hypothesis, measured participants' right hand from the ventral proximal crease of their digit to the tip from a photocopy of the hand scans. These measurements were done using digital Vernier Callipers measuring to 0.01mm and the mean measurement of the two raters was used as a final measurement. The digit ratio for the right hand of each participant was used as 2D:4D ratios tend to be more strongly expressed in males on the right side of the body (Hönekopp & Watson, 2010). The digit ratio for each participant was then computed by dividing the length of the second digit by the length of the fourth digit. The 2D:4D ratio is an inverse relationship, as a smaller 2D:4D ratio indicates higher levels of testosterone and a larger 2D:4D ratio indicates lower levels of testosterone.

Once participants had completed the study they were given a debrief to read, which they could take with them for their information and retention (Appendix C). All participants were paid £8 for their involvement in the study plus any extra money that they had earned on the BART, which was rounded up to the next pound. Participants were paid either in gift vouchers (offenders) or in cash (non-offenders). The debrief informed participants of the research goals relating to the study and again reminded them of their anonymity and the parameters of confidentiality both within the study and in any further reports that may be written as a result of the study. It also included the contact details of the head of research and their individual participant number in the event that any participant should wish to later withdraw their data from the study

or ask any further questions relating to it. Participants were also verbally debriefed by the experimenter and were encouraged to raise any questions or concerns they may have had regarding the study, their participation or their involvement in the research; it was ensured that time was allotted during the debrief for this purpose.

## Results

To study risk-taking between offenders and non-offenders, the average number of pumps on unexploded balloons was computed on the BART. Table 1 provides the means and standard deviations for the digit ratio measurements of the right hand and the BART scores for both offenders and non-offenders. An independent samples t-test revealed that there was no significant difference between offenders and non-offenders in their BART scores,  $t(91) = 1.09$ ,  $p = .28$ . This indicates that there was no difference in risk-taking between offenders and non-offenders. It also revealed no significant difference between the right hand digit ratio measurements of offenders and non-offenders,  $t(106) = 1.31$ ,  $p = 0.19$ .

**Table 1:** Mean and Standard Deviation for Right Hand Digit Ratio Measurements and BART Scores of Offenders and Non-Offenders.

	Offenders		Non-Offenders	
	Mean	SD	Mean	SD
<b>Right Hand Digit Ratio</b>	.95	.04	.96	.04
<b>BART Score</b>	21.94	6.95	23.66	8.23

A Pearson product-moment correlation coefficient was computed to determine whether there was a relationship between right hand digit ratio and BART scores for offenders and non-offenders. For non-offenders, digit ratio did not correlate with the BART scores,  $r = -.01$ ,  $n = 46$ ,  $p = .94$ . This shows that there was no relationship between non-offenders digit ratios and their BART scores. There was also no correlation between the two variables for offenders,  $r = .11$ ,  $n = 44$ ,  $p = .50$ , which shows that there was no relationship between offenders digit ratios and their BART scores. When offenders and non-offenders were grouped together, there was still no correlation between digit ratio and the BART scores,  $r = .05$ ,  $n = 90$ ,  $p = .61$ . This shows that there was no relationship between all participants right hand digit ratio and their BART scores.

## Discussion

The high prison population and re-offending rates within England and Wales has led many researchers to investigate the link between offending and risk-taking behaviour. It is thought that offenders differ from non-offenders in their risk-taking behaviour because of their willingness to engage in criminal activities (Hanoch & Gummerum, 2010; Thornton, 1985). Research in prison populations have shown that offenders have a greater propensity to engage in activities that involve risk-taking, such as substance abuse, unsafe sex and gambling (Fazel, Bains & Doll, 2006; Frost & Tchertkov, 2002; Templar, Kaiser & Siscoe, 1993). The BART is a computerised task that has been designed to measure risk-taking behaviour. Due to the limitations that self-report instruments present in measuring risk-taking, the

BART has been used as a behavioural method of measuring many risk-taking behaviours, such as drug use (Bornovalova et al., 2005), however, it seems that the BART has not been used in previous research to compare risk-taking in offenders and non-offenders. There has also been a growing interest in researchers to determine the role that testosterone plays in risk-taking behaviour. This research has particularly used 2D:4D digit ratio, as several studies have shown it to be a useful method for studying prenatal testosterone in humans (Lutchmaya, 2004; Brown et al., 2002; Berenbaum et al., 2009). Some studies have found that a low 2D:4D, indicating higher levels of prenatal testosterone exposure, is associated with greater risk-taking (Coates, Gurnell & Rustichini, 2009; Schwerdtfeger, Heims & Heer, 2010). Whilst a vast amount of research has been done in this area, there has been no research that studies 2D:4D ratio and risk-taking in relation to offenders and non-offenders.

The aim of this study was to compare offenders and non-offenders on their risk-taking behaviour through the use of the BART. The study also aimed to establish the relationship between 2D:4D ratio and risk-taking on the BART in both offenders and non-offenders. It was hypothesised that offenders would show greater risk-taking on the BART than non-offenders. Furthermore, it was hypothesised that digit ratio would be correlated with risk-taking on the BART for both offenders and non-offenders, but that this relationship would be stronger for offenders.

Contrary to the hypotheses, the data revealed that there was no difference in risk-taking between offenders and non-offenders. That is, offenders were no greater than non-offenders in their risk-taking behaviour. It also found that there was no relationship between offenders' risk-taking and their digit ratios and that there was no relationship between non-offenders risk-taking and their digit ratios. When offenders and non-offenders were grouped together, there was still no relationship found between the two between variables. That is, digit ratio did not predict the risk-taking behaviour of offenders or non-offenders. These findings are in disagreement with findings from previous studies that have shown offenders to be greater risk-takers than non-offenders (Farago et al., 2008; Pachur et al., 2010). The data is also in disagreement with previous research that has shown digit ratio to be related to risk-taking (Coates et al., 2009; Coates & Page, 2009).

The findings from the current study disagree with the majority of research that has previously been undertaken regarding risk-taking in offenders; however it does support some research in this area. Stewart and Hemsley (1984) found that there were no differences between offenders and non-offenders in their sensation seeking tendencies and Wilson and Daly (2006) found that compared to students, young offenders were less likely to be time discounters. Similarly, Hanoch and Gummerum (2010) found that offenders were greater risk-takers in the health domain, but offenders and non-offenders showed no difference in their risk-taking tendencies in the ethical, financial, social or recreational domains on the Domain-Specific Risk-Taking Scale (DOSPERT). The researchers suggest that the lack of difference between offenders and non-offenders in the other four domains could be due to the fact that offenders have fewer opportunities to take risks whilst in the prison environment. It is also suggested that their ability to take financial risks may be diminished because they were unable to earn money whilst in custody. This could relate to the current study as the offenders were within 16 weeks of their prison release. It may be possible that these offenders were also unable to earn money

whilst in custody and so have a diminished ability to take financial risks, especially whilst they may still be adjusting to life outside of prison. Another way in which this could relate to the current study is that 93% of offenders reported being unemployed and 82% reported having a weekly income of less than £100. The ability of the offenders to take financial risks may be diminished as many were unemployed and on a low income. Being on a low income could possibly mean that the offenders have to be more careful with their finances and therefore may be less likely to take financial risks. Offenders were told that they would receive any money that they earned on the BART at the end of the study and may have minimised their risk-taking in order to obtain the maximum amount of money available to them. In using money as an incentive for taking part in the research, it may be possible that the need for money was over-riding risk-taking propensity and that some participants were more conservative with their risk-taking behaviour, especially those who reported a low income.

In contrast to the findings from this study, the BART has been shown to measure a range of risk-taking behaviours, such as weekly alcohol consumption and increased risk-taking in smokers (Skeel et al., 2007; Lejuez et al., 2003). The BART was developed in order to provide a more comprehensive measure of risk-taking and was designed to measure actual risky behaviour (Lejuez et al., 2002). A study by Skeel et al., (2007) found that there may be evidence to suggest that there are benefits in using behavioural measures, such as the BART, along with personality variables as a multi-method approach to studying risk-taking propensity. This suggestion was made in line with the findings from their study indicating that behavioural measures and self-report personality measures both offered different aspects in terms of predicting risk-taking behaviour. Skeel et al's., (2007) study also found there to be little relationship between the BART and another behavioural measure of risk-taking, the Bechara Gambling Task (BGT; Bechara et al., 1994) and other studies have found discrepancies between performance-based risk measures (Lejuez et al., 2003). This could suggest that although the BART is designed to correlate with scores on self-report constructs (Lejuez et al., 2002) they could be measuring different areas of risk-taking and therefore it may be beneficial to use these various methods together in a multi-method approach when studying risk-taking.

The findings from the current study support some of the research conducted on the relationship between 2D:4D ratio and risk-taking behaviour. Whilst the vast majority of research in this area supports the idea that there is a relationship between 2D:4D ratio and risk-taking behaviour, a few studies have produced mixed or null findings. Pearson and Schipper (2009) failed to find a relationship between 2D:4D and risk-taking. Other studies have also produced mixed and negative results when studying the relationship between 2D:4D and financial risk-taking. Apicella, Dreber, Campbell, Gray, Hoffman and Little (2008) studied the relationship between testosterone and risk preferences in an ethnically heterogeneous sample of university students and found there to be no correlation between 2D:4D and financial risk-taking. Sapienza, Zingales and Maestripieri (2009) also found similar results in their ethnically heterogeneous sample of university students and Dreber and Hoffman (2007, as cited in Coates & Page, 2009) found that a lower 2D:4D was negatively correlated with greater financial risk-taking in an ethnically homogeneous sample of participants, but found no relationship between 2D:4D and financial risk-taking in an ethnically heterogeneous sample of participants. Apicella et al., (2008) suggested that the relationship between 2D:4D and risk-taking may only be shown in

homogenous samples. This is supported by Stenstrom, Saad, Nepomuceno and Mendenhall's (2011) study, which accounted for ethnic heterogeneity and found a greater number of significant correlations between risk-taking and digit ratio. Ethnicity has been found to show differences in 2D:4D ratio (Manning, Stewart, Bundred & Trivers, 2004), which could explain the findings in the current study, as participants did not provide information about their ethnicity. Accounting for ethnicity in the current study may have produced different findings; therefore future research that replicates this study should consider accounting for ethnicity in participants.

Several limitations should be considered for the current study. Firstly, the sample size was limited, therefore it may not be possible to generalise these results to the wider population. The sample of offenders was especially limited to a small number of participants as only clients from the FOTO project in Plymouth were used in the research, whereas previous studies using prison populations had access to a larger pool of participants. Research that has used prison populations may also have access to a wider range of participants; therefore a larger sample size may be necessary in future research. Using offenders from a prison population may also be necessary for future research to gain more accurate results.

A second limitation to the current study is that the offenders were not prisoners at the time of taking part in the study. Offenders were within 16 weeks of their prison release, whereas previous research has used offenders within the prison population in order to measure risk-taking (Farago, Kiss & Boros, 2008; Pachur, Hanoch & Gummerum, 2010). Offenders may not have shown any differences in their risk-taking behaviour in comparison to non-offenders in the current study because they may have already begun the rehabilitation process in order to reintegrate back into the community. Offenders attended the FOTO project on a voluntary basis, therefore in order to complete the 16 week programme they would need to be motivated to change their behaviour and get their life back on track after their release. FOTO clients were assigned mentors in order to help them obtain this goal, which could mean that they were refraining from risk-taking behaviour in order to help turn their lives around and to reintegrate back into society as law abiding citizens. This could indicate why there was no difference in the risk-taking behaviours between offenders and non-offenders.

Future research exploring the relationship between 2D:4D ratio and risk-taking behaviour in both offenders and non-offenders is warranted given that no research has previously studied this relationship in offenders in comparison to non-offenders. More research in this area is needed in order to verify the findings of the current study.

Whilst the current study used the 2D:4D as a proxy of androgenisation, there are various other methods that have been shown to be predictive of risk-taking behaviour. Performance on the Baron-Cohen, Wheelwright, Hill, Raste and Plumb (2001) social sensitivity test has been shown to be a proxy for prenatal testosterone exposure. Higher performance on this test has been associated with lower prenatal exposure to testosterone, with women typically scoring higher than men. Performance on this test has also been found to be predictive of financial risk-taking (Sapienza et al., 2009). As previously mentioned, various methods of measuring risk-taking behaviour have been shown to measure different areas of risk-taking. Future research could look at studying a wide range of proxies of androgenisation,

comparing them to various different measures of risk-taking in order to establish the strongest combination for determining risk-taking behaviour.

It seems that the current study is the first to research the risk-taking behaviours of offenders in comparison to non-offenders using the BART. It also seems that it is the first to study offenders and non-offenders in order to establish the relationship between their 2D:4D digit ratio and their risk-taking behaviour assessed by the BART. The study found no evidence that there are any differences between the risk-taking behaviour of offenders and non-offenders or that there is any relationship between their risk-taking behaviour and their 2D:4D ratios and there appear to be a number of possible explanations for this. It is evident that further research is needed in this area to be able to generalise the findings of this study to the wider population.

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