

Handedness and Laterality: Relations to General and Creative Intelligences.

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Abstract

The aim of this study was to determine if both directions of handedness (left/right/ambidextrous) and levels of laterality (extreme/mixed/split) have relationships with general and creative intelligence respectively. This study employed a quasi-experimental cross sectional design to examine direction of handedness and levels of laterality predictability on general and creative intelligences. Forty two fifth class children - aged 10-11 years and from an urban Irish primary school, - first completed the Lateral Preference Questionnaire (LPQ) to determine which groups, in relation to handedness and level of laterality, they were a member. They then completed the New Non-Reading Intelligence Test (NNRIT) and Wallas and Kogan's assessment of creativity to establish their general and creative intelligence. Direction of handedness had a significant relationship with general intelligence, implying that right handed individuals have higher general intelligence than their left counter parts. There was no significant result for either the direction of handedness or levels of laterality with creative intelligence. In relation to levels of laterality and general intelligence, the result was also not significant, but was approaching significance. The split-laterality group had the highest mean in both general and creative intelligence, with the mixed laterality group having the lowest each time. Further research suggestions and limitations for the current study are included.

1. Introduction

1.1 General Introduction

The left and right side of history is an unforgiving report. It is a narrative consisting of myths and folklore intertwined with value systems. From the Maori's of New Zealand to the natives of Morocco to the Holy Bible itself, evidence of left and right symbolism and associations, both negative and positive, is rife (Corballis, 2012). The word 'left' actually derives from the Anglo-Saxon word 'lyft' meaning 'weak' (Zoran, 1998). It is more typically common to have negative connotations and associations with the left than the right (Corballis, 2012). Although there are exceptions to this including the Chinese who pay special tribute to the left side (Grante, 1953). On the whole however, it is the right that is viewed as the more positive and preferable side while also more superior than its counterpart (Corballis, 2012). There is little doubt that the different values and weighting of one side over the other begins with handedness (Corballis, 2012). The right hand is the hand explicitly used to shake hands, salute somebody, swear on the Holy Bible, bless yourself, laying on of hands and it is used for honourable tasks like eating within the religion of Islam (Corballis, 2012). Why then does handedness have such an influence on myths and value systems? It is potentially that handedness is so poorly understood despite years of observation and speculation (Corballis, 2012). It is also perhaps because humans are so different and unique in comparison to all other species (Corballis, 2012). There is a response to this discussion of how handedness has become an influence of myths and value systems: Human misunderstanding and human consciousness both potentially impact the development of myths and values in the social system.

One of the most important documents signed in international legal and social history is the 'Good Friday Agreement'. This agreement was signed in Northern Ireland after a bleak

three decades referred to as 'The Troubles'. In 1998 upon signing this agreement, Tony Blair, Britain's prime minister at the time, uttered an unusual statement: "I feel the hand of history upon our shoulders" (McManus, 2013, p.84). Blair, himself, had just signed the historical agreement with his right hand while Bertie Ahern, Taoiseach of Ireland at the time, signed it with his left. Both represented a different hand of history, both physically and symbolically (McManus, 2013). This study will first consider how these leaders, Tony Blair and Bertie Ahern, differed in the most obvious way that day, examining both left handedness and right handedness and its relationship with intelligence, both general intelligence and creative intelligence. The study will then investigate if there is a relationship between laterality and both general and creative intelligence respectively. Laterality is the preference of one side over another and can be assessed in four different ways which include handedness, footedness, earedness and eyedness (Loffing et. al, 2016). As mentioned previously, the different values and weighting of one side over the other begins with handedness (Beaton, 1985). Due to that, handedness is the manifestation of lateralization of the brain, hand preference is believed to affect a person's overall cognitive skills (McManus, 2002). Handedness has played a big part in previous research, in particular left handedness, so it is imperative to begin at this point, and then begin to extend the research some more (Beaton, 1985; Hardyck & Petrinovich, 1977).

Extending the research is achieved by examining laterality and its relationship with creative and general intelligence. By noting the laterality of a person it is possible to discover if they have extreme right sided dominance or left sided dominance or mixed-handedness (no real preference of side). Rather than only defining someone as left-handed and right-handed based on which hand they choose to write with, it is also important to consider lateral preferences for a number of different activities e.g. kicking a football (foot), looking through a key-hole (eye), listening to something at a low volume on a speaker (ear). From an

amalgamation of these, we can gain a more comprehensive judgement on the relationship handedness and laterality has on intelligence. A person will usually be more right or left dominant sided as true ambidexterity is rare. These results, compared with intelligence scores, will give a true indication of whether intelligence is linked to laterality and handedness. Intelligence is the capacity to be able to think and to problem solve, to thrive and to gain something from every new experience (Hunt, 2010). It is also a person's adaptability to novel situations. Intelligence is important as it influences a range of human behaviours (Hunt, 2010). Since intelligence tests question basic intellectual functions, it is appropriate to use these tests in this study in order to compare the different groups of handedness and levels of laterality, thereby hopefully providing a viable conclusion on the current topic.

This chapter will first consider research pertaining to right handedness and left handedness examining general statistics, the over representation in certain domains of left handers and the uneven distribution of left handers on an intelligence scale. From this, a number of studies will be discussed considering this over presentation and uneven distribution before considering creativity and its long associated link with left handedness. The conversation will then advance to how the degree of strength of handedness rather than direction of handedness, and thus degree of strength of laterality rather than direction of laterality, could potentially be more important to consider, and how this study utilises this as an extension on previous research in this area. Intelligence, along with how best to measure it, will then be deliberated in more detail before reviewing the rationale behind the study and finally exploring what is hypothesised.

1.2 Right and Left Handedness

Among left handed leaders like Bertie Ahern stands Barack Obama, Osama Bin Laden, David Cameron, and Bill Clinton to name but a few. Most species on earth are roughly 50% left handed and 50% right handed (Annett & Annett, 1991). However the

human race is quite different with approximately one in ten of the world's population being left handed, yet a large proportion of this 10% seem to be extremely successful and talented in their own rights (Wright, 2007). From research, it has been shown that left-handers are over represented in certain areas like chess players (Gobet and Campitelli, 2007; Oremosu et al., 2011), among musicians (Kopiez et al., 2006), mathematicians (Annett and Kilshaw, 1982) and artists (Prete and Vellante, 2007). Benbow (1986) suggested that this superiority of left-handers stems from the idea that left handed individuals are more likely to have a well-developed right hemisphere. However, in a recent meta-analysis, left handers have been shown to be over represented among the intellectually challenged (Papadatou-Pastou and Tomprou, 2015). This illustrates an image of over representation of left-handers at either ends of an intellectual scale in comparison to their right-handed counterparts. While left handedness has been associated with superiority and giftedness, it is imperative to note that it is also linked to intellectual challenges as well, thus over representation at both extreme ends of the intellectual scale.

The figure of 10%, mentioned above, seems to be consistent throughout history and different cultures. However, where the culture discriminates against left handed people, the percentage of left handed people is rather less. For example, Japan only reports 5% of their population as left handed, this could be due to their conformist society which discourages people to own up to left handedness as it is viewed as a negative trait (Wright, 2007). This unfortunate situation has been similar in Ireland in the past and therefore could have skewed left handed and right handed statistics up until recently.

There seems to be a discrepancy when analysing left and right sided dominance in that more men than women are left handed (12% > 8%), it has been said that a man is twice as likely to be left handed than a woman (Wright, 2007). There also seems to be a rather large proportion of people with special needs who are left handed as well as also a large proportion

of gifted people e.g. Leonardo Da Vinci, Albert Einstein, Bill Gates (Wright, 2007). Fry (2006) wrote that when considering rare conditions, like Down Syndrome, Epilepsy and Cerebral Palsy, the ratio of left- to right-handers is more like 50:50 rather than 1:10. It has been said that left handed people are disadvantaged in many ways as they live in a right handed world. In that sense, they are one of the world's largest minority groups (Lantin, 2003). If the majority of the population who are right handed thought more about the operation of school desks, violins, camera and tins, they would find that the world is designed for right handers and that all these things have contributed to the constant stigmatisation, as referred to earlier, in culture, linguistics and religion, of being left-handed.

Cherbuin and Brinkman (2006) tested individuals on two tasks orientated around the use of each brain hemisphere, and required transfer between hemispheres, or use of both hemispheres at the same time. Left-handers tended to have faster connections between both sides of the brain suggesting they can use their brain more efficiently than a right side dominant candidate (Cherbuin and Brinkman, 2006). This is due to the information being more quickly processed, meaning that a cognitive advantage a left handed person has can be seen in sports and playing video games (Cherbuin and Brinkman, 2006). This study also showed that while roughly 10% of the population is left handed, 25% of Major League baseball players are left-handed ('How Baseball is Rigged For Lefties', 2008). This could be due to the cognitive advantage referred to by Cherbuin and Brinkman (2006). It could also be due to the advantage that left-handed people have in interactive sports like boxing, tennis, baseball and cricket (Hangemann, 2009). As majority of players are right handed, right-handed players are more accustomed to playing with fellow right-handers and due to different movements and orientations left-handers would naturally make, this throws the right-handed opponent slightly. However this advantage does not extend to non-contact sports like diving, swimming and gymnastics etc. (Hangemann, 2009).

A very recent study conducted by Loffing (2017) puts the left handed advantage hypothesis to the test. Loffing (2017) collected multiple data and found a pattern. In sports where there is a short time constraint, left-handed athletes seem to excel. This includes sports like baseball, cricket and table tennis compared to slower response time sports like squash or tennis (Loffing, 2017). Loffing (2017) proposed that the left-hander's advantage is directly linked to the sports' time pressure. The recurrence of left-handed players who are listed in elite rankings increased significantly from 8.7% to 30.39% within sports with time pressure and there was a distinct left-hander overrepresentation only seen in baseball, cricket and table tennis (Loffing, 2017).

The link between left-handedness and creativity has long been speculated. Creativity is sometimes defined as divergent or lateral thinking and requires subjects to make novel associations between everyday elements (Coren, 1995; Lindell, 2011). McManus (2002) spoke about the right brain hemisphere being more advanced in left-handed people than right-handed people. This is due to the dominant left side of a person's body being controlled by the opposite side of the brain. If the brain is more developed on this side that could suggest again better inter-hemispheric and dual-hemispheric action which could suggest more creativity as creativity occurs on both sides of the brain and not just on the right as once thought (Cherbuin and Brinkman, 2006). Thus, by increasing interaction between two sides, creativity increases. It has been shown in multiple studies that left-handers have a creative advantage over their right counterparts while some studies find no difference in scores of right handers and left handers. (Heilman, 2005). However, higher proportions of left-handers are found in creative occupations like music, art and architecture (Corballis, 2014).

Kaufman and Gregoire (2015) show a link between creative thinking and innovation to qualities like independence and not conforming to society. These qualities can develop in children and adults who develop a mind-set of an outsider. This is due to left-handers being one

of the largest minority groups in the world, as mentioned earlier, and are thus subjected to living in a very biased right handed world (Lantin, 2003). Daily struggles of door handles, toilet flushes, kettles and spiral notebooks all contribute to the left-hander becoming an outsider and developing this mind frame. This state of mind can prime an individual to develop the qualities of independence and non-conformity linked to creativity (Kaufman & Gregoire, 2015).

1.3 Strength of Handedness

From a review of research into handedness and cognition taken from a range of experimental studies, it emerged that the main predictor of cognitive performance was not the direction of handedness (left or right), but the degree of strength the preference was for one hand over another (consistent versus inconsistent) (Prichard, Propper & Christman, 2013). Strongly handed individuals, both right and left, were at a slight disadvantage compared to the inconsistent handedness or mixed handedness individuals which were the inconsistent left-handed and ambidextrous (Prichard et al., 2013). They carried out at least one day-to-day task using their non-dominant hand, this could be due to years of training and developing the non-dominant hand to perform activities. In these cases the results suggest that inconsistent handedness is associated with increased interhemispheric interaction and also increased access to processes localised to the right hemisphere (Prichard et al., 2013). As discussed earlier, this suggests the presence of a potentially more creative brain as both sides of the brain are being utilised and there is easier and more access to the right side of the brain in particular, which is less common.

1.4 Intelligence

It has long been discussed how one should measure intelligence. There is an ongoing debate about the amount of types of intelligence that exist and how they are represented in the brain, as well as how it is measured remains (Sternberg, 2003). Generally most psychologists

believe that there is a generalised intelligence factor referred to as 'g' that includes the general characteristics of intelligence mentioned previously. (Gottfredson, 1997; Sternberg, 2003). This g accounts for the differences in intelligence among people (Gottfredson, 1997; Sternberg, 2003). Furthermore individuals with a higher g learn faster than those whose g score is lower (Sternberg, 2003). However there is also more evidence to suggest that along with g there are specific intelligences referred to as 's'. It is within s that creativity is measured specifically (Sternberg, 2003). Brody (2003) discussed that the many specific intelligences are actually correlated and represent to some degree, g. Both s and g will be assessed in this study – general intelligence and specific intelligence. The specific intelligence being tested will be creativity, due to its link to left-handedness in research previously mentioned. General and creative intelligence tested with levels of strength of laterality are not plentiful. Thus, it is hoped that this study will provide a baseline for further research within this vast area, as there are many various ways of testing both general and creative intelligence.

1.5 Rationale of the Study

This study will extend on previous literature through comparing intelligence scores of people based on their laterality and not just their handedness (Hicks & Beveridge, 2013; Hicks & Dusek, 1980; Piro, 2009; Wilson & Dolan 1931). Considering people such as Leonardo De Vinci, Albert Einstein, Pele, Lady Gaga, and Bill Gates, to name but a few, shows a pattern occurring - they appear to have one thing in common: They are all successful people in their own right. Moreover, they have something else in common: They are all left handed (Wright, 2007). Van Den Brink-Budgen (2011) wrote that of the last eight presidents of the USA, five of them have been left handed. All of them are also very successful in different ways. This leads to a question: Why is this the case? If there is only approximately 10% of the population left handed, the distribution of this ten percent seems to be uneven

within the special needs and gifted spectrum of people. There seems to be a discrepancy between such a small percentage of the world's population and such a large proportion of this group receiving fame and honour for their works. What was the strength of their direction of laterality? Instead of focusing primarily on their direction of handedness, expanding this to levels of strength of laterality could potentially help research to answer this question.

Now is the optimum time within the current education system to test people for right or left sided dominance as research from previous eras was potentially skewed, as mentioned above, due to an education system that involved forced laterality (changing the hand used to write from the left to the right) (Mastin, 2012). It is not enforced by educators to favour one side over the other at present, whereas this has been the case in the past. Also, currently there are more students with diagnosed special needs than ever before. This is relevant to this particular study, because, as previously mentioned, the distribution of left-handers is uneven and is overrepresented at either end of an intellectual scale, as special needs affects one intellectual ability, this could have an effect on results from studies in the past and could be a potential factor in this study's results and is thus worth being aware of in order to notice patterns and distributions among results.

The reason (or reasons) explaining why the majority of people are right-handed remains unknown. Neuroscience is still a new field of research without definitive and determined conclusions. Further research is needed and it is very important in areas like brain damage and in particular memory damage, since the language centre in the brain is *usually* on the opposite side to a person's dominant hand (but not always) (Springer & Deutsch, 1993; Damasio & Damasio, 1992). Research regarding left-handedness is essential to aid patients recovering from brain damage (LaPointe et al. 2010). This highlights the importance of studies regarding laterality to help research in neuroscience progress and thus, assist in the recovery of individuals who have suffered brain damage.

All research regarding left-handedness is important. A study was conducted which focused on how being left or right handed can influence a person's emotions (Brookshire & Cassanto, 2012). To perform motivation approach and avoidance actions the hemispheric activity was greater in the right hemisphere when left handed and vice versa (Brookshire & Cassanto, 2012). It was consistent with the way they typically use their dominant and non-dominant hands to perform these actions (Brookshire & Cassanto, 2012). An imperative implication of this is when caring for people who suffer from mood or anxiety disorders. One method of treatment is brain stimulation in order to increase neural activity in the left hemisphere ('How Left Handed People Think and Feel Differently', 2016). However, this could be 'detrimental' to left-handers, and not representative of the help they require ('How Left Handed People Think and Feel Differently', 2016). Therefore, any further study in the left-handed field and related fields is helpful to society as a whole, and should be conducted. There is a lot still unknown in this particular area. Although this study is not focusing on a person's emotions, the concept of emotions is still relevant as it is investigating both handedness as a part of laterality as well as trying to determine if there is a relationship with intelligence. This could aid in trying to fully understand the potential reasons why something like this would be detrimental to a left-hander. It could be a case that handedness and laterality are so important in a range of medical disorders that conducting laterality tests might be necessary in order to help these patients overcome their problems.

One huge issue that has emerged from all the relevant literature is a possible reason why previous research has failed to determine consistently if there is a relationship between handedness/laterality and intelligence. Research has shown that it is because too much emphasis has been placed on direction rather than degree of strength - as shown in the study conducted by Prichard, Propper and Christman (2013). This study will address this issue and

will include strength and direction of not only handedness but the other three fundamentals of laterality including footedness, earedness and eyedness.

Considering all these various statistics, it will be interesting to begin to understand whether the dominance of one side of a person's body, and in particular left-side dominance and mixed- dominance, shows a relationship with that person's general intelligence.

1.6 Hypotheses

In conclusion the studies and literature reviewed above have demonstrated the extensive research associated with handedness, laterality and intelligence. This study will seek to include handedness as part of overall laterality of subjects to get a clearer picture of what side is really dominant, as being right handed does not necessarily indicate complete right side dominance for all parts including eye, ear and foot. It can be noted how often the left-versus-right argument has been viewed potentially incorrectly and perhaps it should not be discussed in terms of right versus left but rather in strength of dominance. For the purpose of this study, consistent (extreme laterality) and inconsistent (mixed and split) laterality.

When testing intelligence both *g* and *s* will be examined separately. For this study it is important to test *s* as creativity, due to the existing potential myth that 'left-handed people are more creative'. It must be examined again to see if it is in line with current data pertaining to this subject.

Therefore, it is firstly hypothesized that there is a direct link between extreme handedness and general intelligence levels (Hypothesis 1). It is also hypothesized that there is a direct link between extreme handedness and creative intelligence levels (Hypothesis 2).

It is hypothesized that there is a relationship between levels of laterality (extreme/mixed/split) and differences in general intelligence levels. (Hypothesis 3)

Finally, it is hypothesized that there is a relationship between levels of laterality (extreme/mixed/split) and differences in creativity intelligence levels (Hypothesis 4).

It is hoped that this study will inspire the world of Psychology to investigate further as well as to incorporate aspects of this study in their own for the benefit of human kind.

2. Method

2.1 Participants

Participants in this study consisted of primary school children from an urban, catholic, vertical school in Dublin from the age of 8 years 2 months to 11 years 10 months in accordance with the NNRIT Level 3 test. This sample was selected based on opportunistic sampling as the researcher works in the school as a Learning Support teacher. Informed consent was granted by the principal, acting in *loco parentis* (see Appendix A). Although the researcher works in this school, they had not previously taught the participants in this study. As the school has a population of over 300, the author was not familiar with any of the participants. Children who did not have a disability which would affect their laterality and potentially cause forced laterality were eligible for this study. A total of 42 children (N=42) were selected from 5th Class in this DEIS2 school. 23 of the participants were female and 19 were male. This was the entire population of 5th class. The choice of class for the sample was taken, at random, by the principal. No incentive was offered to the children, and they were informed that participation in the study was completely voluntary.

2.2 Design

This study was a Quasi-Experimental cross sectional study. For the first two hypotheses the groups consisted of the following:

Table 1: An outline of variables used in hypothesis 1 and 2.

Hypothesis	Independent Variable (IV)	Dependent Variable (DV)
1 and 2	Right Handed (Group 1)	<u>General Intelligence score</u> (NNRIT result)
	Left Handed (Group 2)	<u>Creative Intelligence score</u> (Wallas and Kogan's test result).
	Ambidextrous (Group 3)	

The independent and dependant variables utilised can be seen above in *Table 1*.

Group 3 consists of individuals who are ambidextrous which is the ability to use their right and left hand equally well. For the remaining two hypotheses the groups were compiled in the following way:

Table 2: An outline of variables used in hypothesis 3 and 4.

Hypothesis	Independent Variable (IV)	Dependent Variable (DV)
3 and 4	Group 1 – All right or all left side dominance preference - <u>Extreme</u> <u>Laterality Group</u>	<u>General Intelligence score</u> (NNRIT result)

Group 2 – At least three left
or three right side Creative Intelligence score
dominance preference - (Wallas and Kogan’s test
Mixed Laterality Group. result).

Group 3 –Two right side
dominant and two left side
dominant – Split Laterality
Group.

For each group represented in *Table 2* there are four participants of laterality being tested. The four components being assessed are hand, ear, eye and foot. The participants were assigned to one of the three groups based on the direction and strength of each laterality predictor (hand, foot, eye and ear), which emerged when they completed the laterality tests that determined right/left dominance of handedness, footedness, earedness and eyedness using the Laterality Preference Questionnaire as a categorising tool.

2.3 Materials

2.3.1 New Non-Reading Intelligence Test (NNRIT)

The NNRIT (New Non-Reading Intelligence Test) manual and test level three (*see Appendix B*). The NNRIT is a general ability intelligence test that doesn’t require the subject to read. It is presented orally by a teacher (researcher) and involves verbal reasoning and general intelligence to be tested independent of reading.

There are four sub-tests to the NNRIT, each containing two examples and then a further 15 completed by the participant independently. There are seven second pauses between each one. The sub-test B is recognising the odd one out, while sub-test D is about recognising opposites. Both depend on knowledge of meanings and the ability to compose relationships between them. Part C is analogies which requires recognition and application of relationships while sub-test A is knowledge of idiomatic expressions and synonyms (Young, 2012).

The reliability of the NNRIT is high. Its internal reliability measured by Cronbach's alpha was 0.91 for NNRIT 3 and the 90% confidence limits were +/-5 (Young, 2012). The standardised scores used are also measured against Irish norms.

2.3.2 Laterality Preference Questionnaire (LPQ)

Lateral Preference Questionnaire Norms is used to determine laterality of each child and place them into relevant group through scoring (*see Appendix C*). As the sample consists of children aged 10/11 the children were asked to show the tasks with real and pretend objects rather than answer a questionnaire verbally how they would perform each of the activities in the LPQ. Lateral preferences were assessed in each of the four parts of the LPQ.

The first part consisted of 11 items regarding hand preference for writing, drawing, using a toothbrush, opening a bottle, throwing a ball, using a hammer (pretend), holding a tennis racquet, sawing a rope with a ruler, using a spoon, using an eraser, and striking a match (off a surface where the match cannot be lit).

The second part consisted of four items regarding foot preference for kicking a ball, trampling down a plastic cup, stepping up onto a chair, and putting the first of a pair of shoes on.

The third part consisted of four items: looking through a small gap, looking in a jar to see how full it is, looking through a microscope, and looking through a magnifying glass.

This determined eye preference.

The fourth and final part consisted of four items regarding ear preference. It involved listening to people behind a closed door, listening to the ticking of a wrist watch, listening to someone (researcher) who whispers, and listening to see whether an elevator is arriving.

Some parts of the test were potentially dangerous. For example, when a child would be engaging with a hammer or some matches. These parts were thus adapted to suit the current study and sample.

For the entire LPQ which consisted of 23 items, the possible responses were “left” (score 0), “both” (score 1) or “right” (score 2) (Van der Elst, Meijs, Hurks, Wassenberg, Van Boxtel & Jolles, 2011). However, as mentioned earlier, for this study the LPQ was used as a categorising tool to assign each participant into the relevant group. For example if a participant emerged as left handed and was left footed, left eared but right eyed through the LPQ testing they would be assigned to Group 2 for Hypothesis 1 and Hypothesis 2, and Group 2 for Hypothesis 3 and Hypothesis 4.

The LPQ items were previously tested and considered to be good indicators of four different lateral preference factors (the hand, foot, eye, and ear preference factors) and it also was considered to be indicators of the four lateral preference factors, which in turn predicted a single underlying general lateral preference factor (Van der Elst et al. 2011).

2.3.3 Wallas and Kogans's Assessment of Creativity

Wallas and Kogan's (1965) Assessment of Creativity involves participants being asked to come up with as many items as possible that contain a specific component. An example of this for this study would be items that contain wheels. Scoring consists of four

individual components: Originality, Fluency, Flexibility and Elaboration. If answers are only given by 5% of the sample then it is awarded 1 point, while answers given by only 1% of the sample are given 2 points. Fluency is measured by totalling the number of responses a participant gives. Flexibility is the amount of different categories the participant has responded with. Elaboration is the amount of detail given, any extra detail is given 1 point and any further detail beyond that given another. This creative intelligence was selected as it best suits and is most typically administered in a classroom setting. It can also be administered by anyone, there is no training required.

2.4 Procedure

Ethical approval for this current study was granted by the Dublin Business School Psychology Department Board of Ethics. A Statutory Declaration for working with children was sent to the Ethics Board accompanying the researcher's proposal. The principal granted permission for the study in *loco parentis* (see Appendix A).

Testing took place over two days. Each child completed both the NNRIT and Wallas and Kogan's Assessment of Creativity in a group and classroom setting. Each participant completed the LPQ individually outside of their own classroom to avoid contamination of the sample through one child copying the other, rather than using their own dominant hand/ear/eye/foot.

The children are divided into two classes: both the NNRIT and Wallas and Kogan's Assessment of Creativity were administered by the researcher to each class separately and in their own classroom. The NNRIT was firstly administered, followed by the Assessment of Creativity, during a morning session and on the same day. The Wallas and Kogan's Assessment of Creativity was delivered over an hour and fifteen minutes time period. The children were told about the topic an hour before the assessment and then had fifteen minutes

to write down their answers. This was to avoid contamination of the sample - whereby children may discuss their ideas orally at break time – while still allowing enough time for the participants to be creative. Over the course of another school day the LPQ was also administered by the researcher by removing children individually from their classroom and bringing them to another classroom in the school building in order to participate. It is important to reiterate here that the researcher is a primary school teacher, as it is a requirement of the NNRIT that it be administered by a primary school teacher.

After this data was collected, the teacher informed the researcher what participants had diagnosed special needs and they were indicated on the candidates and codes document with an asterisk (*). This code containing the children's names and assigned numbers is kept electronically under password protection on the researcher's computer with a strong anti-virus programme. This was done for aiding analysis as there has been some research which has linked children with special needs to non-right handedness and atypical laterality.

2.5 Data Analysis

The data analysis of this current study was conducted using IBM SPSS Statistics Version 24 for Windows. Analysis of Variance was completed using One Way ANOVA. This test can be used to determine if there are statistically significant differences between the means of multiple groups. It is appropriate for this study as there are three groups (as explained above). The means of the NNRIT results along with the Wallas and Kogan's Creative Intelligence test results of these four groups of participants will be used to determine whether there is a significance difference between the intelligence observed in those with extreme or mixed laterality.

2. Results

The sample consisted of 42 children (N=42), 23 female and 19 male participants, aged 10-11 with a mean age of 10.94. The results are now divided into three main sections. The results of Hypotheses 1 and 2 regarding direction of handedness and intelligence (general and creative) will be described in the first section based on the findings from an Independent Sample T-test. The second section examines Hypothesis 3, relating to general intelligence and types of laterality (extreme/mixed/split), any significant differences that may be found from the one-way ANOVA conducted are reported. The third and last section discuss Hypothesis 4, that deal with creative intelligence and levels of laterality (extreme/mixed/split), also based on the findings from the one-way ANOVA completed.

3.1 Hypotheses 1 and 2

Before the results were examined there were three potential groups which included a right-handed group, a left-handed group and an ambidextrous group. However, after examination of the results it was evident that there were no participants suitable to be in the ambidextrous group, as during the LPQ administration no candidate had qualified for the researcher to select the option 'both/either' rather than 'left' or 'right' when completing the LPQ. As a result of this, an Independent Sample T-Test was conducted as an alternative to the originally intended one way ANOVA.

An Independent Samples T-test found that there was a significant difference between general intelligence of right handers ($M = 107.03$, $SD = 14.80$) and left handers ($M = 94.8$, $SD = 4.76$). ($t(17.86) = 3.78$, $p = .001$, $CI (95\%) 5.43 \rightarrow 19.03$). Therefore the null can be rejected. These results would suggest that direction of handedness is significantly predictive of general intelligence levels and that because the right handed general intelligence results are

greater than the left handed general intelligence results, right handed people are more generally intelligent than left handed people.

An Independent Samples T-test found that there was not a significant difference between creative intelligence of right handers ($M = 31.3$, $SD = 13.24$) and left handers ($M = 25.8$, $SD = 13.22$). ($t(40) = .871$, $p = .389$, $CI (95\%) -7.25 \rightarrow 18.25$). Therefore the null is accepted. This result insinuates that direction of handedness is not significantly predictive of creative intelligence results.

3.2 Hypothesis 3

The next hypothesis deal with general intelligence and its relationship with extreme laterality (completely right or left side dominant), mixed laterality (three right side and one left side dominant or three left side and one right side dominant) and split laterality (half right and half left side dominant). The proportion of groups in this study can be identified in *Figure 1* and general descriptive statistics are shown in *Table 2*.

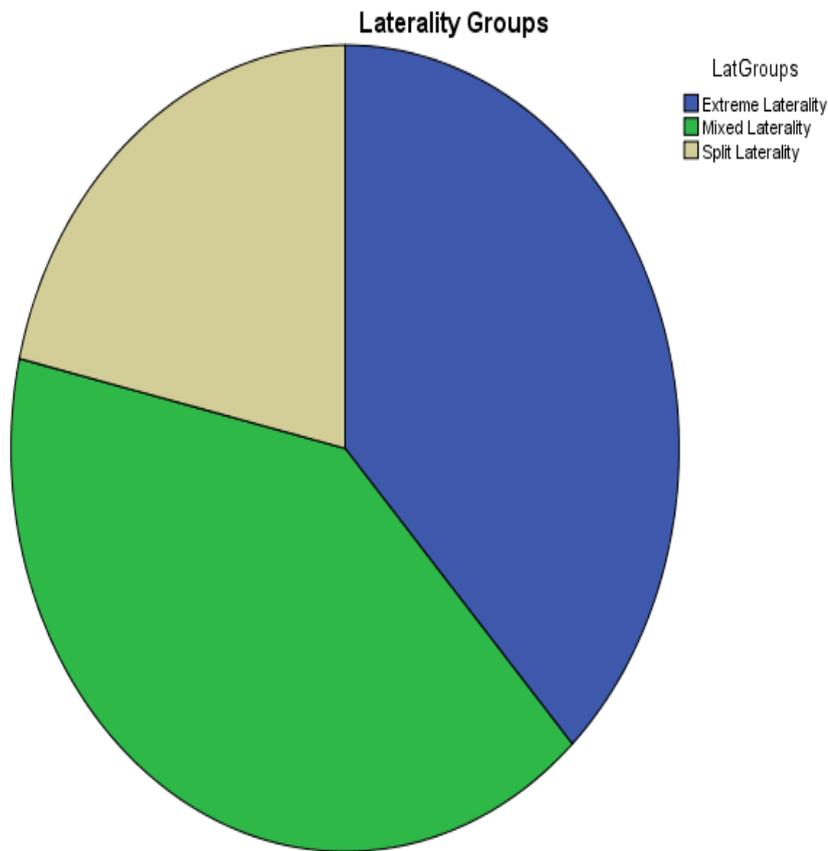


Figure 1: Pie Chart displaying Laterality Groups proportions within current study.

Table 3: Descriptive statistics of variables used in hypothesis 3.

Variable	Groups	Mean	SD	Minimum	Maximum
General Intelligence	Extreme Laterality	108.63	13.97	85	130
	Mixed Laterality	99.35	15.60	70	130
	Split Laterality	111.89	8.99	102	130

A one-way analysis of variance showed that general intelligence did not differ significantly between the three groups ($F(2, 39) = 3.04, p = .059$). This result illustrates there is a difference in the general intelligence results between the three laterality groups but not a

statistically significant one. They show that levels of laterality are not significantly predictive of general intelligence levels. As it is approaching significance, it is displayed more vividly in *Figure 2*.

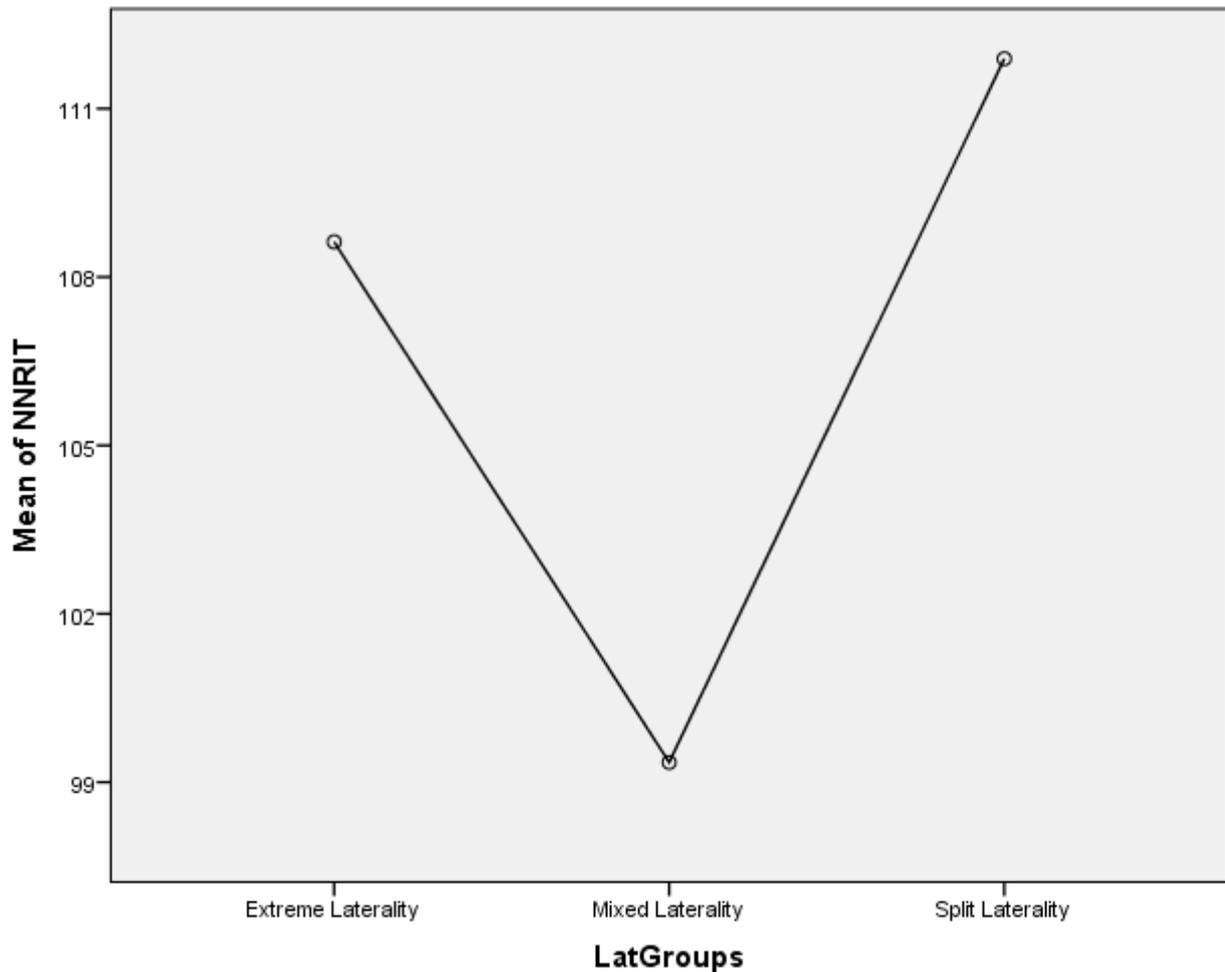


Figure 2: Means plot showing differences in levels of general intelligence among different levels of laterality groups.

3.3 Hypothesis 4

The final hypothesis examined creative intelligence and its relationship with groups of participants with extreme laterality (completely right or left side dominant), mixed laterality (each participant being oriented with either three right sided dominated laterality and one left or three left side dominant and one right), or split laterality (half right and half left side

dominant). In *Table 4* the descriptive statistics of the variables utilised in hypothesis 4 can be observed.

Table 4: Descriptive statistics of variables used in hypothesis 4.

Variable	Groups	Mean	SD	Minimum	Maximum
Creative Intelligence	Extreme Laterality	31.25	11.38	10	56
	Mixed Laterality	28.06	13.01	14	56
	Split Laterality	30.64	16.76	17	63

A one-way analysis of variance showed that general intelligence did not differ significantly between the three groups ($F(2, 39) = .71, p = .5$). The result suggests that this study did not agree with the idea that creative intelligence has a significant relationship with levels of laterality. It also illustrates that levels of laterality (extreme/mixed/split) are not significantly predictive of creative intelligence levels.

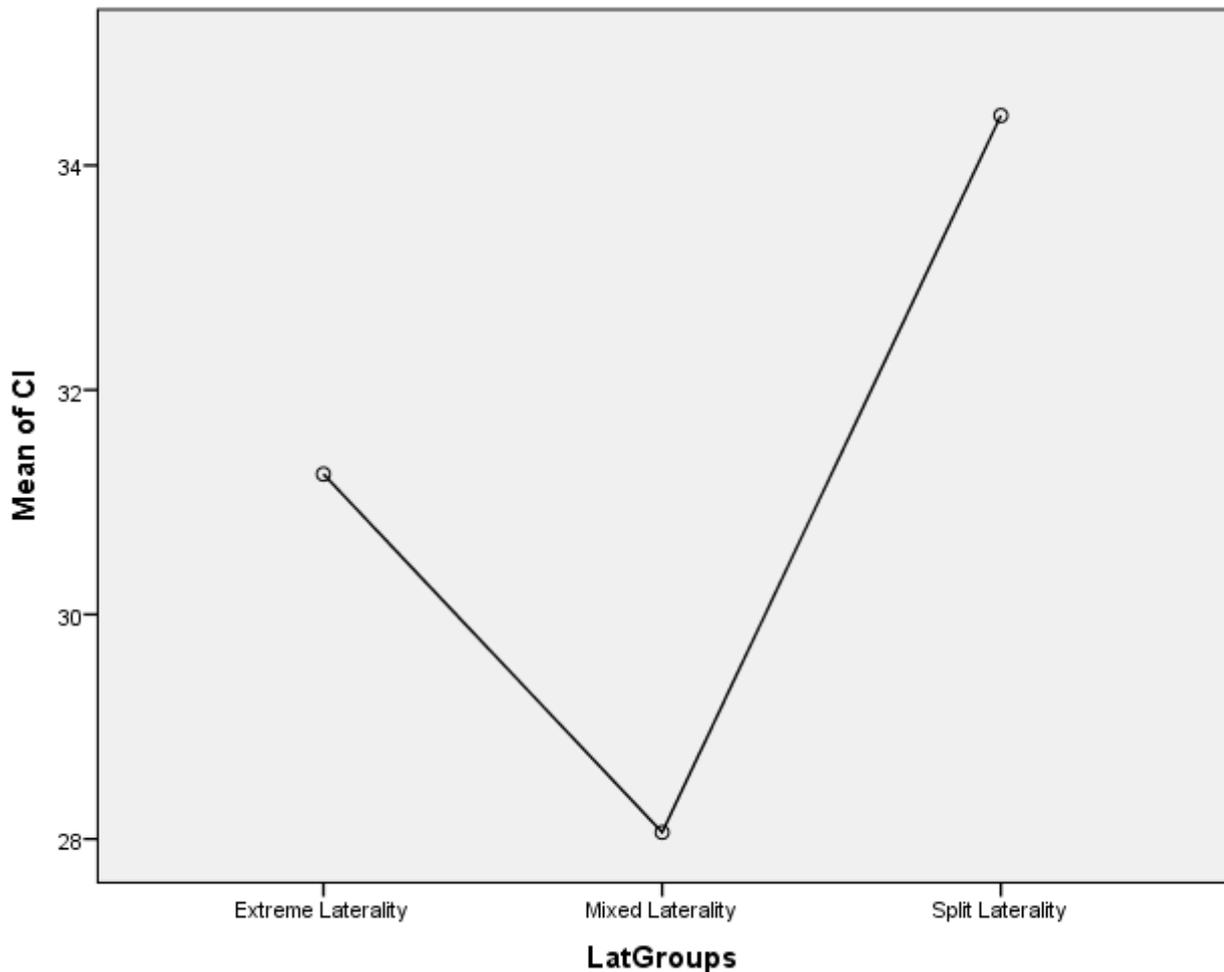


Figure 3: Means plot showing differences in levels of creative intelligence among different levels of laterality groups.

From Figure 3, a decrease in creative intelligence can be observed in group 2 – the mixed laterality group. This is worth noting as it resembles Figure 2 where the means of general intelligence saw a familiar shaped line plot. This indicates that mixed laterality groups, which is made up of participants who are three right side dominant and one left as well as three left side dominant and one right, did not score as highly as their extreme and split laterality counterparts when completing both the general intelligence and creative intelligence test.

3.4 Other Relevant Findings

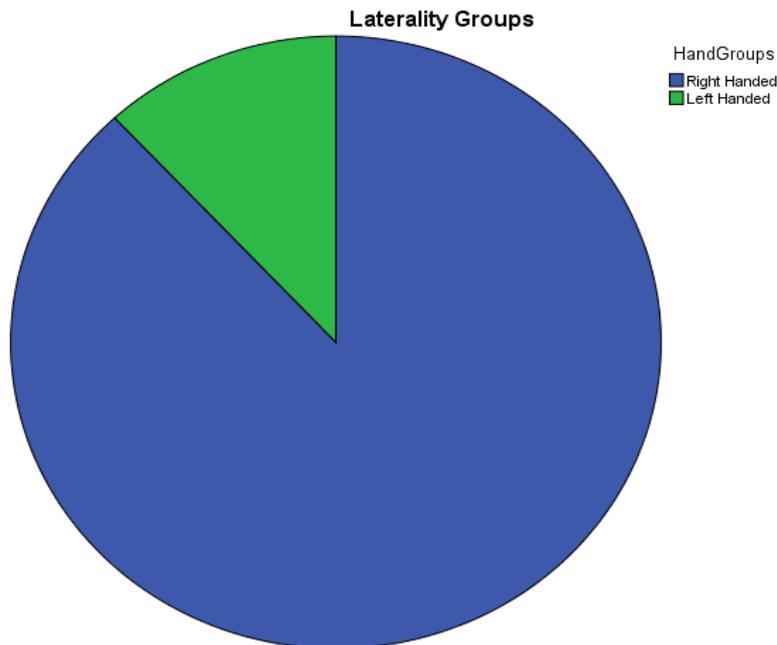


Figure 4: Pie Chart displaying Right Handed and Left Handed proportions in the study.

Figure 4 displays the right and left handed groups that emerged in the results of the study. Left handers surfaced as 11% of the group, 5 participants out of 42. This is in line with international standards of 10-12%.

Another relevant finding was within the solely left handed group of 5 members, 3 out of the 5 participants (60%) were male. Of the entire male population of the sample, 20% were left handed, in contrast to 10% of the entire female population of the sample being left handed.

As well as this, within the whole sample there are four participants with diagnosed special needs. Two of these four participants are left handed, with 3 participants having split laterality and one having mixed laterality. There were no participants with special needs with extreme laterality.

4. Discussion

This study employed a quasi-experimental cross sectional design to investigate the relationship between left handedness and right handedness in terms of creative and general intelligence respectively. The study also sought to examine the relationship between levels of laterality (extreme/mixed/split) and general intelligence as well as creative intelligence. This was carried out with a sample of 5th class pupils aged 10 – 11. The leading aim of the overall research was to try to understand why 10% of the world's population are non-right handers and an incredible proportion of this 10% appear to be gifted in some way or at the other end of the scale, it appeared to be associated with special intellectual needs (Wright, 2007; Papadatou-Pastou and Tomprou, 2015). To do this, this study looked at, and then beyond, the right handed/left handed debacle and considered handedness as one quarter of laterality alongside footedness, earedness and eyedness. Intelligence, general and creative, were then considered. While a review of the literature found that there was an abundance of international research addressing specifically left handedness and intelligence, there was no research that, firstly, examined the levels of laterality as explicitly as in the groupings here, and, secondly, included similar potential predictions of general and creative intelligence. Furthermore, in an Irish context, research regarding left and right handedness and intelligence, as well as levels of laterality and intelligence has been relatively unexplored. Being a country with an education system which only recently stopped the forcing of laterality (to always be right hand dominant), it is surprising that there is not currently more research being done in this area on a national scale. Because of this shift in the reduction of forced laterality in Ireland, collecting data regarding left and right handedness will hopefully not be as skewed as it once was. Perhaps due to that Ireland is still a primarily catholic country and within this religious system the left has strong negative connotations. This has held back research as there are still generations living that would potentially not openly admit

or show they were left side dominant which would have an effect on the results. The findings of this study will be discussed in detail and references to the hypotheses which was proposed at the start of this study will be constructed. Previous research will be utilised to draw both parallels and distinctions to this current paper. Limitations of the study will then be explored, followed by implications for future research, the strengths of the study will then be discussed before the conclusion of the current study will be formulated.

The results of the first hypothesis (there is a direct link between direction of handedness and general intelligence) found that the direction of handedness was significantly predictive of general intelligence levels and that right handed people were more generally intelligent than left handed people. This statistic has to be accompanied with an air of caution as the left handed group contains only five participants, and in order to be able to make that statement definitively, more even groupings would be necessary. However, the finding does fall in line with some literature including the UK National Child Development Study, a longitudinal study, which showed a difference in general intelligence scores and, similar to this study, it was also right-handers who were slightly more intelligent (McManus, 2013). Although it was first thought that this result was due to the prevalence of special needs among the left handed group, even after removing scores below 80, the result, interestingly, did not change (McManus, 2013). In addition, the results here in this study, reflected what international expectations of the prevalence of left handed individuals with special needs are. Papadatrou and Tomprou (2015) spoke about intellectually disabled individuals being nearly twice (1.98 times) as likely to be left-handed and 2.66 times more likely to be non-right handed compared to the general population. They continued by explaining that by hypothesizing that exactly 10% of the world's population are left-handed, then the prevalence of left-handed individuals with special needs is 19.6%. (Papadatrou & Tomprou, 2015). In

this current study, 50% of the participants with special needs are left handed which is even more than what Papadatrou and Tomprou anticipated (2015).

Although direction of handedness was found to be predictive of general intelligence, conversely, it was not predictive of creative intelligence scores. This reaffirms the side of literature which disagree that left handedness and creativity are directly linked (Heilman, 2005). The notion of higher proportions of left-handers being found in more creative occupations like music, art and architecture (Corballis, 2014) is dismissed by McManus (2013) who discussed the lack of evidence to indicate that left handed people are more creative. It seems this study provides an argument for his own views, and that direction of handedness does not predict creative intelligence.

As discussed previously, strongly handed individuals (right and left) were at a slight disadvantage in terms of cognitive performance compared to the inconsistent handedness or mixed handedness of individuals (Prichard et al., 2013). This study contained no mixed handed participants, and thus, if these results were applied to laterality and this meant the extreme laterality individuals were at a disadvantage in comparison to mixed and split laterality, this study would be in contrast to Prichard et al.'s findings. This study found that types of laterality and general intelligence were both approaching significance. Perhaps if the sample was larger it would reach significance, but until that research is conducted, it is inconclusive if levels of laterality significantly predict general intelligence. This study did conclude that there was a difference in the laterality groups and unlike the study just mentioned, it was established that the mixed laterality groups intelligence were at a disadvantage compared to the split laterality and extreme laterality groups. The IQ of these groups were higher than the mixed laterality groups. Interestingly, the left handed participants in the study were all members of the split and extreme laterality groups, except for one member. Perhaps left handers are more likely to have split laterality or extreme laterality, and

if so, both these groups have higher IQ's than mixed laterality which would coincide with some of the literature already mentioned which supports left handedness predicting general intelligence. Sulzbacher, Thomson, Farewell, Temkin & Holubkov (2009) wrote a paper focusing on crossed dominance. This concept (crossed dominance) corresponds to mixed laterality in this study, and demonstrated that mixed laterality does not predict poor intelligence but still they agreed the argument commonly persists that mixed laterality (crossed dominance) does predict poor intelligence. Yeo et al. (1997) established that developmental instability has an influence on the variation in the lateralization of cognitive skills as well as handedness. From both of these studies, as well as this current study, there could be a potential notion drawn that variations in laterality come from developmental instabilities in the brain, which in turn causes atypical lateralisation and rather than this predicting intelligence, perhaps this is a symptom of it. This could also account for left handers uneven distribution at either end of an intellectual scale, as previously discussed.

Finally, the last hypothesis (relationship between creative intelligence and levels of laterality) obtained a result that levels of laterality do not predict creative intelligence scores. What is worth pointing out is how the pattern of results resembled the results of general intelligence and levels of laterality. Split laterality has the highest mean, with extreme laterality next in line and, again, mixed laterality in last place. The similarity in the results is interesting. It supports the idea that mixed laterality could be associated with lower intelligence and that extreme and split laterality could be associated with higher intelligence. Prichard et al. (2013) talked about how the degree of strength is what is important and not the direction. This theory is supported here.

4.1 Limitations and implications for future research

At first, the unsuccessful attempt by this research to find a significant differential effect on particular variables is disappointing. However, on reflection, there are a number of reasons for these null effects which have contributed to the limitations of this study. The following aspects appear likely to have contributed to the effectiveness of the current study: small size of sample; creative intelligence measures; and measuring intelligence.

4.1.1 Sample Size

The entire sample of the study was $n=42$. As left handers of the sample (11%) fell in line with international statistics (10-12%), this meant the study contained only 5 actual left handed people. This causes issues when using these 5 participants as a group versus a group of right handed participants containing 37. Calculating the results for these two groups is problematic when using them for comparison methods. For a fair comparison there needs to be more evenly distributed groups. Future research should employ methods that enable the recruitment of roughly the same amount of left handed participants as right handed participants to gain a more comprehensive and realistic picture.

4.1.2 Creative Intelligence Measures

The creative intelligence measure used was Wallas and Kogan's (1965) Assessment of Creativity. It was selected largely due to its administration technique, it can be administered by anyone, there is no training required and because it is typically administered in a classroom setting, it suited this current study. Its reliability is not being questioned, however its scoring method is a comparison only of the sample itself. There are no baseline scores with corresponding levels which indicate *how* creative a person is. An implication of this is that the scores that feature in the results of this study are only comparable within this study and could not be used for outside comparison. This is due to the highest score in this

sample being a reflection of the ‘most creative’ participant in this study, except, within another sample they could be one of the least creative. It is not definitive that the highest creative intelligence score found in this current study means that this person is *very* creative. They may be the *most* creative within this sample, but future research should perhaps be wary of that and not compare their results to other studies if doing the same assessment. It may also be useful to find another creative intelligence assessment without such weaknesses and limitations. Due to its nature, creative intelligence is extremely subjective and researchers need to keep this in mind when conducting further research in this area.

4.1.3 Measuring Intelligence

As mentioned earlier, intelligence and how to measure intelligence has long been discussed. In this study, general intelligence was selected along with creative intelligence. Sternberg’s (1986) triarchic theory on intelligence describes three types of intelligences: practical intelligence; creative intelligence; and analytical intelligence. Sternberg (1986) admitted analytical intelligence could be measured with certain standard IQ tests but creative and practical intelligence could not be measured in the same test. If this study were to take Sternberg’s theory as the rubric to follow, one intelligence would remain unmeasured – practical intelligence. It is difficult to say which intelligences should be measured as it is so widely disputed within the world of Psychology. Contemplating the theory of intelligence Howard Gardener put forward in 1983 regarding multiple intelligences (like ‘*s*’, as discussed earlier), this study, once again, is lacking in measuring these kinds of intelligences, including, for example, musical intelligence and bodily kinaesthetic intelligence. This is also due to the ongoing debate on the subject of ‘*g*’ and ‘*s*’ intelligences. The implications of this are that the researcher is obliged to pick certain intelligences because the measurement of all intelligences would not be viable. It is not only the choosing of particular types of intelligences which causes issues in this area of research, but also the method of

measurement, which would run into problems as it is another largely disputed area. The best way to proceed with future research is for the researcher to consider what exact intelligence they want to measure for their study considering their hypotheses and the literature they have reviewed. If it is emotion-related, perhaps emotional intelligence could be measured, or if it is sports-related, bodily-kinaesthetic intelligence may be the most relevant to be measured.

4.2 Strengths of the study

Although there were multiple limitations of the study, it also included many strengths. Firstly, the study used standard scores when interpreting the NNRIT results and not the usual percentile results which are used more commonly for this particular assessment among educators in the field of education. This allows for other research comparisons in the future, as it is standardised with Irish norms. As well as this the aim of the study to consider the appeared discrepancies of non-right handers on either end of an intellectual scale was attempting to begin filling a gap in research both on an international scale and a national scale. The Irish context is optimum for this research presently, due to the fact that, as mentioned before, forced laterality has existed within the education system for so long. Within the sample itself, even though it was a convenient sample randomly chosen by the principal of the school for inclusion in the study, the ratio of boys to girls was almost even. There were 23 females and 19 males, meaning that gender specific results could be considered fairly. Lastly, the NNRIT that was selected to be the instrument to measure general intelligence is a non-reading test meaning that children whose results sometimes suffer during reading tests, for example children with dyslexia, would get a more accurate result pertaining to their intelligence and not a skewed score resulting from reading difficulties due to special needs.

4.3 Conclusion

To conclude, this study investigated the relationship between left handedness and right handedness in terms of creative and general intelligence respectively. It found that the direction of handedness was significantly predictive of general intelligence levels and that right handed people were more generally intelligent than left handed people. This study also found that 50% of the participants with special needs are left handed. While direction of handedness was found to be predictive of general intelligence, it was not predictive of creative intelligence scores, helping to disseminate the untruth of the myth that left handed people are more creative. Progressing from handedness to laterality, it was found that types of laterality and general intelligence were approaching significance. From this current study, as well as relevant literature discussed, there could be a potential notion drawn that deviations in laterality stem from developmental instabilities in the brain, which could be the origins of atypical lateralisation and rather than this predicting intelligence, potentially it could be a symptom of it, which would also account for the left handed population having uneven distribution at either end of an intellectual scale, as previously discussed. It was also found that there was no relationship between creative intelligence and levels of laterality, but similar to the results of the analysis of general intelligence and levels of laterality, interestingly, split laterality held the highest mean, with extreme laterality next and mixed laterality with the lowest mean in both intelligence tests. It is hoped that this study will be replicated to some degree, and with a larger sample, even more conclusive results could be drawn. With this, will come further insights into the mysterious world of laterality.

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Appendix A: Consent Letter

Principal Consent Form.

Your students are invited to be a part of the research study 'Laterality: the relationship between extreme handedness and general and creative intelligence.' I hope to include a sample from 5th class within your school. This is a very important study which will help to create a better understanding of the relationship between laterality and extreme handedness and laterality with both creative and general intelligence. Participants will be required to take part in the New Non-Reading Intelligence Test, Laterality Preference Questionnaire and Wallace and Kogan's Assessment of Creativity. New-Non Reading Test will test the subject's general intelligence and ability. The Laterality Preference questionnaire will examine the preference of one side over the other in the form of hand, ear, eye and foot. Wallas and Kogan's assessment of creativity examines are asked to come up with many possible items that contain items that contain a specific component, such as with wheels, round things, or things that make noise.

Participation is completely voluntary. Your students do not have to participate in the research and they may withdraw at any time. Furthermore their anonymity will be protected as no names will be recorded. The data will be stored safely and nobody will have access to it other than the researcher. This research has been approved by the Ethics Committee in the Dublin Business School.

For this study we require only principal consent and student consent. Students will provide consent by ticking a box at the beginning of the questionnaire. Parental consent is not necessary as Principal is acting in loco parentis.

However, if it is school policy to seek parental consent then it will be obtained prior to commencing data collection. If you have any questions please contact Meghan Tuohy by email at

Consent

I declare that I have read and understood the above information sheet. I also give permission for my students to be involved in the Research Project.

Principal's name: Mary O' Mahony

Signature: MARY O' MAHONY Date: 14/12/2017

Appendix B: NNRIT Test 3

First name _____ Last name _____ Class _____ School _____	Today's date _____ Date of birth _____ Age: yrs _____ mths _____ Raw score _____ /60 SS _____																																																																																										
																																																																																											
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NNRIT 3



1	c	b	r	s
2	p	d	c	w

1	s	j	h	c
2	g	j	d	b

3	t	s	m	l	3
4	f	c	h	v	4
5	b	t	c	w	5
6	c	s	u	g	6
7	h	g	t	m	7
8	c	b	m	r	8
9	w	m	y	d	9
10	p	s	t	h	10
11	f	h	k	s	11
12	t	s	g	w	12
13	o	g	p	f	13
14	b	h	l	k	14
15	c	l	s	d	15
16	r	b	w	p	16
17	d	a	t	c	17

3	s	p	c	w	3
4	y	t	c	h	4
5	g	i	f	o	5
6	p	d	b	l	6
7	l	s	w	p	7
8	g	c	b	c	8
9	s	r	g	t	9
10	d	t	h	l	10
11	h	g	d	a	11
12	p	m	d	w	12
13	g	c	r	s	13
14	v	h	b	m	14
15	s	f	g	m	15
16	r	h	d	f	16
17	r	h	s	t	17

A score (max. 15)

B score (max. 15)

Appendix C: LPQ

Name:

Classroom:

	Right	Left	Either
Writing			
Drawing			
Toothbrush			
Opening bottle			
Throwing ball			
'Hammer'			
Tennis			
Rope and ruler			
Spoon			
Rubber			
Matches (open)			
Kicking ball			
Plastic cup (trample)			
Stepping on chair			
Putting shoes on			
Small gap (eye)			
Jar (eye)			
Microscope			
Magnifier			
Closed Door (ear)			
Wrist Watch			
Someone Whispering			
Elevator (ear)			