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Elaborato Finale

**FROM CHARLES DARWIN TO SHERLOCK HOLMES:  
CONTRIBUTIONS OF EVOLUTIONARY PSYCHOLOGY IN  
FORENSIC SCIENCE INVESTIGATION**

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## **SUMMARY**

### Introduction

Evolutionary psychology (EP) is a discipline born between evolutionary biology, cognitive science, and physical anthropology. It's both a theoretical and practical scientific discipline which principal purpose is to study human behavior, in order to understand the biological and evolutionary causes that generated it. Evolutionary psychology finds its roots in the Darwinian theory, considering human behavior as the product of adaptations to recurring problems in the ancestral environment, which evolved as functional results of natural or sexual selection forces. A branch of this discipline, Evolutionary forensic psychology, is a burgeoning field which explores the application of science and the profession of psychology to questions and issues relating to the law and legal systems. It make use of empirical methodologies, as fieldwork, the method mutually exclusive of multiple hypotheses, and the deductive investigative logic, which allowsto create psychological profiles. These profiles are based on objective data from the analysis of the cases, and aim to predict and understand biological motives that led people to commit violent behavior. Evolutionary forensic psychology promise to be a useful tool to study and analyze the variables of different situations, in order to assist and direct police and defensive investigations.

In this PhD research I addressed different aspects and applications of this discipline. In the specific, during my research period at Philippe-Pinel research institute of Montréal, Canada, I have explored the application of evolutionary psychology in the study of *presence*, a psychological state akin to perceptual illusion, first identified by cognitive and cyber psychology, and here analyzed as *sexual presence*.

However, my research has mainly concentrated on the study of the adaptive value of maternal infanticide, with a special focus on the phenomenon of maternal neonaticide, here meant as "reproductive disinvestment", and its social and legal implications. Following this line of research, as part of the Evolutionary Forensic Psychology Laboratory, I experienced the role of the investigative psychologist, attending as defensive consultant a case of suspected maternal infanticide. Applying the methodology of evolutionary forensic psychology, I conducted, with my supervisor, an interdisciplinary research between forensic psychobiology and legal medicine, aiming to verify the validity of tympanic and rectal temperature in estimating the time of death. I suggest that the results of this research had relevant consequences both in medico-legal and investigative domain but, above all, our outcomes brought to light a number of methodological errors, that are systematically made in our country during the crime scene investigation and the rescuing in outdoor conditions. According to these findings, I have analyzed the European Guidelines for resuscitation in wild conditions, and I took in exam what happens in the practice in our country. Finally I present representative cases, where the time of death was a crucial data, but its erroneous interpretations led to controversial verdicts.

### The sexual presence model

#### *Introduction to the concept of presence*

Presence is defined as a psychological state or subjective perception causing an individual to give into the illusions created by a computerizing system., it's a real feeling of been immersed in a virtual environment, mediated by emotional states and biological predispositions.

In the practice, it is very important to define and measure the feeling of presence, since Virtual Reality is used to for a large number of purpose. Most recent research show

how useful virtual reality is in medical context, both in diagnosis and treatment assessments. According to this, here is presented a special kind of the feeling of presence, the *sexual presence*, which describes the particular psychological cognitive and physical feeling generate by the experience of sexuality through different media, as erotic movies or chat-line.

#### *Aim of the theory*

To define and understanding sexual presence is crucial to maximize and recall this feeling in an experimental context. In fact, virtual reality is a powerful tool to assess sexual fantasies and interests in individual. Especially with child molesters, and sexual offenders. To get the highest level of presence, which integrates, the users need as much identification as possible inside the virtual system, which should be provided by the developer through a convincing and controlled motor and perceptual illusion. For all these reasons, this work aims to identify the features of sexual presence, and how to induce it in an experimental situation.

#### *Main aspects of the sexual presence model*

Sexual presence is an evolutionary phenomenon featured by motivational emotional and physical feelings, that an individual experiences when exposed to internal or external stimuli, like erotic movies, on-line erotic chat and most of all, sexual fantasies. Sexual presence arises from an adequate combination of form and contents, and is strictly related to sexual arousal and sexual behavior. Following Riva and colleagues (2011) this work identified three sub-processes of sexual presence: proto, core and extended presence, which are deeply connected, and represent both in conscious and in unconscious behaviors and in intents that features sexual presence, and they differ from male and female. This three level model should be well-known when we need to induce sexual presence in experimental context. Thus to maximize sexual presence it is

important to identify the erotic imagery features for each participant, and to develop a virtual environment which is significant to the participant.

### *Conclusion*

This model could be particularly useful in the study of paraphilias and sexual behavior disorders using virtual reality systems. In fact, at the present time, the research team I worked with at the Philippe-Pinel Institute, is applying this model in the study of evolutionary hypothesis on rape.

## Mothers Who Kill Their Offspring: Testing Evolutionary Hypothesis in a 110-case

### Italian Sample

#### *Introduction and aim*

The killing of a child by own biological mother has occurred in our species since its origin, most probably in every culture and every population. According to evolutionary theory, the killing of offspring by its own mother may, under certain conditions, represent an evolved behavioural pattern that increases the reproductive fitness of the mother. This research aimed to identify incidents of mothers in Italy killing their own children, verifying if neonaticide (killings of children within the first day of life), infanticide (killing of children within the first year of life), and filicide (killing of children after the first year of life) can be objectively distinguished by psychobiological profiles that might help to prevent them, and testing an adaptive evolutionary hypothesis to explain their occurrence.

#### *Methods*

110 cases of mothers killing 123 of their own offspring from 1976 to 2010 were analyzed. Each case was classified using 13 dichotomic (yes/no) variables. Descriptive



statistics and hierarchical cluster analysis were performed both for cases and variables, and significant differences between clusters were analyzed.

*Results:*

The Italian sample of neonaticides was found to satisfy most evolutionary predictions for an evolved behavioral, emotional and motivational pattern to increase fitness, showing a consistent profile for the offending mothers. All neonaticide cases fall in a single cluster, distinct from all other cases. Infanticide and filicide, on the contrary, do not significantly differ according to the variables measured (marital status, conditions of the body, mothers age, violent killing, other sons, psychopathology, economical condition, suicide, nationality). The common profile of mothers who have committed infanticide or filicide includes psychopathology, suicide or attempted suicide after killing their children, violent killing of their victims, and no attempt to conceal the victims' bodies. These results suggest that maternal infanticide and filicide represent an improper functioning of adaptation, and their profile are much more variable than those of neonaticide offenders.

*Conclusion:*

Our study confirms that only neonaticide is an adaptive reproductive disinvestment, possibly evolved in the remote past, to increase the biological fitness of the mother by eliminating an unwanted newborn and preserving resources for future offspring born in better conditions. I here show that Neonaticide is clearly distinct from infanticide and filicide and therefore should be approached, prevented, and judged differently in penal assessment.

## Why mothers kill newborn: a focus on Italian sample

### *Introduction and aims*

In the light of the results just presented, it has been defined deeply the phenomenon of neonaticide in our country. In line with the literature, our previous outcomes show that neonaticidal mothers are young women, in bad socio-economical situation, who can't grow their offspring, due to a so defined "*reproductive comprehensive instinct*". The socio-biological profile of these women seems very similar to those who decide to have an abortion: renounce to a pregnancy, in this case, doesn't mean to go against the reproductive instinct, but preserve energy and resources for a future pregnancy. Here we compared the profiles of neonaticidal mothers and women who decide to interrupt their pregnancy, in order to identify risk factors and contribute to the prevention of this phenomena.

### *Methods*

35 cases of neonaticide were analyzed. Each case was classified using 7 main dichotomic variables. To analyze possible risk factors, all data have been normalized, based on the actual frequency of the reference populations, in order to have comparable values, according to ISTAT 2002.

### *Results*

This study shows that neonaticide and abortion share similar traits, especially concerning the young age of the women. The profile of these women "at risk" suggests that they are 1) normally at their first birth, 2) usually very young with 3) a great residual reproductive potential and (4) immigrated from another country.

## *Conclusion*

The results here presented might have important implications in therapeutic assessment, as the identification of risk factors, to offer and promote adequate socio-psychological support to at risk future mothers.

## Evaluation of tympanic and rectal temperature measurements to estimate the time of death in accidents in cold water

### *Introduction and aims*

The reliable measurement of core deep body temperature is fundamental to estimate the time of death (TOD) in Hessnge nomogram. The golden standard is measuring through rectal or oesophagus probe. Recently infrared tympanic thermometers (ITT), have substituted in some cases the golden standard. We assisted, as defense consultants, a case of suspect maternal infanticide, where the emergency service revealed a deep temperature of 24.9° C with ITT on a female victim of 2 years old, immersed in a 18° C river. The ITT estimated time of death, which seemed to be the only strong evidence against the mother, was in contrast with the predictions from most other biological and thanatological evidences (bloodgas analysis and myocardium electric activity). I could ascertain that according to the psycho-biological profile, the mother had no motive to kill her daughter. To validate the TOD evidence, this work aimed to provide a reliable correlation between the golden standard and infrared tympanic temperature to be eventually used in this and future cases of TOD measurements in accidents occurring in cold water.

### *Methods*

To compare the ITT and the rectal probe temperature measurements, we tested laboratory rats, in three different conditions: dry alive, immersed alive in 18C° water,

and immersed dead (by cervical dislocation) in 18°C water. To sample infrared temperature, we used 3 infrared thermometers. Genius 3000 A (used in this forensic case, 2 samples) and Genius 2 (the most popular at present in Italian emergency services). The rectal temperature was assessed using a rectal probe connected to a monitor Propaq. We also tested the accuracy of ITT, recording body temperatures on a human volunteer before during and after exposing its right ear to 3 minutes running water at 18°C and subsequently dried.

### *Results*

The Genius 2 stopped registering at 33°C and never resumed recording following the first measurement after the rat was submersed in water. This observation was *a posteriori* confirmed in the user manual, which stated that this thermometer stopped reading below 33°C.

When the rats were submerged in the 18°C running water, the rectal temperature began to decline steadily. The tympanic temperature recorded with Genius 3000A, in contrast, dropped sharply from 34°C to 24°C after the rats were submerged alive in the water. After their deaths, the rectal temperatures continued to decline steadily without major variations, while the tympanic temperature fluctuated above water temperature. On the human volunteer ITT measures immediately fell under 19°C, while the whole body temperature, remained unchanged at 36.5°C. ITT measurements recovered the subject correct body temperature after 33 minutes from water exposure.

### *Conclusion*

In water-related accidents, such as near drowning, infrared ear thermometry is not a suitable method to measure the actual deep body temperature. Further, confirming these results, the temperature readings of the ITT device provide unreliable measurements of

the core temperature. This inaccuracy could lead to inappropriate medical decisions, and thus, we suggest ITT measurements should not be utilised for such cases. Moreover, the use of the ITT Genius 2 is not recommended in emergency settings, especially in case of hypothermia due to his its incapacity to register under 33 C°.

### Errors, Guidelines and Remarks: what happens in the practice?

#### *Introduction and aims*

The results of previous study left a lot of unanswered questions. The bulk of knowledge necessary to diagnosis of the time of death, known as thanatology, is a multidisciplinary field of study, that includes forensic pathology to biology, through chemistry, physics and also forensic entomology., Assessing the victims time of death is a crucial point in forensic practice: it allows investigators to clarify the last hours alive of the victims, it also helps to point out the causes of death and, moreover, it's crucial to substantiate suspicious alibis. Nevertheless, before becoming a crime scene, the environment and setting where a body is found, is a place where someone need to be rescued and treated by medical assistance, and this interferes with thanatological requirements. Here we aim to analyze what happens in the forensic and medico-legal practice in our country.

#### *Methods*

We have analyzed the European guidelines for resuscitation in wild conditions as hypothermia and drowning in cold water, with a focus on what are the suggestions for estimating the core temperature, both for the resuscitation procedure and the estimation of the time of death. Then we took in consideration what happens in Italian emergency services and which procedures, if any, they implement in the described conditions. Those data were found on the Hospital's websites, in our Country. Finally, we have examined some relevant cases, taken from the analysis of specialized books and from

the archives of major newspapers that have followed the penal processes reported, where the investigation of the crime scene and the estimation of the time of death were decisive to solve the crime.

### *Results*

The European guidelines for resuscitation are very precise concerning the treatment for a patient affected by injuries due to hypothermia or drowning. But they are not that specific for what concern the use of a particular method to register the core temperature. In the forensic practice the methodology to estimate the TOD is heterogeneous. In Italy, the guidelines to resuscitation are provided just at local level, and it's not even mandatory to have a temperature recording device on the ambulance.

### *Conclusion*

We found out that procedural mistakes and lack of univocal rules in the practice have led to controversial outcomes in legal processes. Our work urges further studies regarding the techniques to estimate the post-mortem period, and suggests an adequate training for the rescue teams members, to provide the best care and to preserve such important evidence as TOD.

### General Conclusions

In this thesis I've explored the applications of evolutionary psychology in the forensic practice, outlining the role of the investigative psychologist. The research outcomes might have both theoretical and practical implications. First, It has been described for the first time the *sexual presence*, which is a phenomena which might be involved in the assessment of paraphilias and violent behavior with virtual reality. Second, it has been found that maternal neonaticide, in our species, has an evolutionary cause, and the neonaticidal woman profile is different from infanticidal and filicide ones. These

suggestions have relevant effects in the investigation phase, in correctional assessment, and also in the definitions of preventive measurement targeted to at-risk future mothers. Third, collaborating as consultant in a case of suspect infanticide, I found that the tympanic temperature, very used in the practice, is not a valuable measure to assess the time of death in extreme outdoor conditions, where the body core temperature is essential. In light of these results, it has been noticed the lack of regulations in our country about the estimating of TOD, and I provide suggestions to improve medico – legal and resuscitation actions in the forensic practice. These studies show the versatility and the practical value of evolutionary psychology in the forensic domain. In fact, the most important outcome of this work is to demonstrate how the techniques and theories learned and explored during three PhDs years, have important applications in the clinical, criminological and forensic practice, and how it could be important to carry on researches in evolutionary forensic psychology, due to its social implications.

## **RIASSUNTO**

### Introduzione

La psicologia evoluzionistica è una disciplina che proviene dall'incontro tra diverse materie, quali la biologia evoluzionistica, le scienze cognitive e l'antropologia fisica. È una disciplina basata sull'approccio scientifico, il cui principale obiettivo è comprendere le cause biologiche ed evoluzionistiche che hanno generato il comportamento umano. La psicologia evoluzionistica affonda le radici nella teoria Darwiniana, che considera il comportamento umano come un prodotto dell'evoluzione dei diversi adattamenti a problemi ricorrenti che i nostri antenati hanno dovuto risolvere in un ambiente ancestrale, presumibilmente plio-pleistocenico. Questi comportamenti si sono evoluti sotto la spinta della selezione naturale e sessuale. Una branca di questa disciplina, la psicologia evoluzionistica forense, è un settore di studio in grande espansione, che studia l'applicazione della scienza e il ruolo di psicologo nell'analisi di aspetti forensi e legali. Questa disciplina si avvale dell'approccio empirico, come lo studio sul campo, il metodo delle ipotesi multiple mutuamente esclusive, e il ragionamento logico-deduttivo, che consente di creare profili psicologici basati su dati oggettivi provenienti dall'analisi dei casi, con lo scopo di comprendere e predire i moventi biologici che portano le persone a commettere comportamenti violenti. Per questi motivi la psicologia evoluzionistica forense si appresta ad essere un valido strumento nell'analisi delle diverse variabili in situazioni differenti, così da assistere e guidare l'operato delle forze dell'ordine e delle indagini difensive.

Durante il mio dottorato, ho potuto esplorare diversi aspetti e applicazioni di questa disciplina. Nello specifico, durante il mio periodo di ricerca all'estero, presso l'Istituto



di ricerca Philippe-Pinel di Montréal, in Canada, ho applicato le teorie della psicologia evolucionistica nello studio del concetto di “presence” uno stato psicologico derivante dall’illusione percettiva, originariamente identificato dalla cyber psicologia cognitiva, e qui analizzato come “sexual presence”.

Tuttavia, la mia ricerca si è principalmente concentrata nello studio del valore adattivo dell’infanticidio materno, con particolare attenzione al fenomeno del neonaticidio, qui inteso come “disinvestimento riproduttivo”, e le sue implicazioni sociali e legali. Grazie a questi studi, in collaborazione con il laboratorio di psicologia evolucionistica, ho collaborato come consulente della difesa, in un caso di sospetto infanticidio materno. Applicando le metodologie della psicologia evolucionistica forense, ho condotto, in collaborazione con il mio supervisor, il Prof. Andrea Camperio Ciani, un ricerca interdisciplinare a cavallo tra la psicobiologia forense e la medicina legale, il cui obiettivo è stato quello di verificare la validità delle temperature rettali e timpaniche nella stima dell’ora del decesso. Il risultato di questi esperimenti potrebbero avere conseguenze rilevanti sia dal punto di vista medico legale che medico investigativo, ma soprattutto, ha mostrato come, nel nostro paese, vengano commessi diversi errori durante l’analisi della scena del crimine e nelle fasi del salvataggio in situazioni estreme. Alla luce di questi risultati ho preso in esame le linee guida per la rianimazione in situazioni estreme, osservando quello che succede nel nostro Paese, portando come esempio dei casi rappresentativi in cui la stima del decesso era un dato fondamentale, ma la cui erronea o incompleta interpretazione ha portato a risultati controversi.

### Il modello della sexual presence

#### *Introduzione al concetto di presence*

La *presence* è un stato psicologico, una percezione soggettiva che fa sì che un individuo sperimenti l'illusione creata da un computer, definibile come una sensazione reale di essere immersi in un ambiente virtuale mediata da stati emotivi e predisposizioni biologiche, nella pratica è molto importante definire e misurare la sensazione di *presence*, in quanto la realtà virtuale ha diverse applicazioni. Recenti ricerche hanno mostrato l'importanza della realtà virtuale nel contesto diagnostico e trattamentale, per questo motivo, in questa tesi viene presentata uno speciale aspetto della *presence*, la *sexual presence*, che descrive la sensazione psicologica, cognitiva e fisica generata dall'esperienza della sessualità tramite diversi media, come ad esempio i film o le chat-line erotiche.

#### *Scopi della teoria*

Comprendere e definire la *sexual presence* è fondamentale per massimizzare e richiamare questa sensazione nel contesto sperimentale. Infatti, la realtà virtuale è uno strumento efficace per testare le fantasie e gli interessi sessuali degli individui, in particolare con i molestatori sessuali e i pedofili. Per raggiungere il massimo livello di *presence*, gli utenti o i soggetti in esame, hanno bisogno della massima identificazione possibile all'interno del sistema virtuale, che dovrebbe essere fornita dai programmatori, attraverso un'illusione percettiva e motoria controllata e convincente. Per tutte queste ragioni, questo studio si pone l'obiettivo di identificare le caratteristiche della *sexual presence* e di come indurla in una condizione sperimentale.

#### *Principali aspetti del modello*

La *sexual presence* è un fenomeno che ha delle basi evolutive, caratterizzato da sensazioni motivazionali, emozionali e fisiche, che un individuo sperimenta quando esposto a stimoli, esterni o interni, come film erotici, chat-line erotiche e, soprattutto, le fantasie sessuali.

La *sexual presence* è generata da una combinazione adeguata di forma e contenuto, ed è strettamente connessa all'eccitazione e al comportamento sessuali. Seguendo le nozioni di Riva e colleghi (2011), questo lavoro identifica tre sub-processi che sottostanno alla *sexual presence*: la *proto la core* e la *extended presence*, che sono strettamente connessi e rappresentano comportamenti ed intenti sia consci che inconsci, e che si differenziano tra maschi e femmine. Questo modello a tre livelli dovrebbe essere ben noto, nel momento in cui si vuole indurre la massima sensazione di presence in un esperimento. Quindi, per massimizzare la sensazione di presence è importante identificare l'immaginario erotico di ogni partecipante e sviluppare un ambiente virtuale che sia significativo per il partecipante.

#### *Conclusioni*

Questo modello potrebbe essere particolarmente utile nello studio delle parafilie e dei disturbi del comportamento sessuale tramite realtà virtuale. Infatti, attualmente, il gruppo di ricerca a cui ho partecipato al Philippe- Pinel Institute, sta applicando questo modello nello studio delle ipotesi evoluzionistiche sullo stupro, tramite realtà virtuale.

#### Madri che uccidono: studio su un campione di 110 casi in Italia

##### *Introduzione e obiettivi*

L'omicidio di un bambino da parte della madre biologica accade nella nostra sin dalle origini, in ogni cultura e popolazione. Secondo la teoria evoluzionistica, l'omicidio materno della prole può, in alcune circostanze, rappresentare un comportamento adattivo che si è evoluto per aumentare la fitness riproduttiva della madre. Questa ricerca si pone l'obiettivo di identificare l'incidenza delle madri che uccidono i loro figli nel nostro paese, verificando se il neonaticidio (l'omicidio dei neonati entro le 24 ore dal parto), l'infanticidio (entro il primo anno di vita) e il figlicidio (dopo il primo di

vita), possono essere oggettivamente distinti in profili psicobiologici che possono aiutare a prevenirli, e testare le ipotesi evoluzionistiche adattive per spiegarne le dinamiche.

### *Metodi*

Sono stati analizzati 110 casi di madri che hanno ucciso 123 bambini, dal 1976 al 2010. Ogni caso è stato classificato utilizzando 13 variabili dicotomiche. Sul campione sono state effettuate analisi statistiche descrittive e una analisi per cluster, sia per casi che per variabili, analizzando poi le differenze significative tra i gruppi.

### *Risultati*

Il campione italiano dei neonaticidi ha soddisfatto tutte le ipotesi evoluzionistiche, per un pattern di comportamenti emozioni e motivazioni volte ad aumentare la fitness riproduttiva, mostrando un profilo consistente per madri neonaticide. Tutti i casi di questo tipo sono stati raggruppati in un unico cluster, diviso dagli altri casi. Infanticidio e figlicidio non differiscono significativamente per nessuna delle variabili prese in esame (stato civile, condizioni del corpo, età della madre, modus operandi, psicopatologia, suicidio e nazionalità). Il profilo della madre che ha commesso infanticidio e figlicidio è caratterizzato da psicopatologia, suicidio o tentato suicidio, modus operandi violento e nessun tentativo di nascondere il corpo della vittima. Questi risultati suggeriscono che il figlicidio e l'infanticidio siano due comportamenti maladattivi, e il loro profilo sia molto più variabile di quello delle neonaticide.

### *Conclusioni*

Questo studio conferma che solo il neonaticidio è un disinvestimento riproduttivo adattivo, evolutosi in un passato remoto, con lo scopo di aumentare la fitness

riproduttiva materna eliminando un figlio non voluto e preservandole risorse per una prole future, in condizioni migliori. Il neonaticidio si è dimostrato essere chiaramente distinto dall'infanticidio e come tale dovrebbe essere affrontato, prevenuto e giudicato in tribunale.

### Perchè le madri uccidono I neonati: focus su un campione italiano

#### *Introduzione e obiettivi*

Alla luce dei risultati appena presentati, è stato analizzato più in profondità il fenomeno del neonaticidio nel nostro paese. In linea con la letteratura, i nostri precedenti risultati mostrano che le madri neonaticide sono donne giovani, in condizioni socio-economiche difficile, che non possono crescere i propri figli, a causa di un cosiddetto “istinto riproduttivo complessivo”. Il profilo socio-biologico di queste donne sembra essere molto simile a quello delle donne che decidono di abortire: ovvero rinunciare alla gravidanza in questo caso non significa andare contro all'istinto riproduttivo, ma conservare le energie e le risorse per una gravidanza futura. In questo lavoro ho confrontato il profilo della madre neonaticida e della donna che decide di interrompere la propria gravidanza, con lo scopo di identificare i fattori di rischio e contribuire alla prevenzione del fenomeno.

#### *Metodi*

Sono stati analizzati 35 casi di neonaticidio, ogni caso è stato analizzato utilizzando 7 variabili dicotomiche. Per comparare i possibili fattori di rischio tutti i dati sono stati normalizzati sulla base delle frequenze della popolazione di riferimento, secondo i dati forniti dall'ISTAT 2002.

#### *Risultati*

Lo studio ha messo in luce come il neonaticidio e l'aborto abbiano aspetti simili, soprattutto per quanto concerne la giovane età delle donne. Il profilo di queste donne a rischio suggerisce che esse sono 1) alla loro prima gravidanza 2) solitamente molto giovani con 3) un grande potenziale riproduttivo residuo e 4) immigrate da un paese straniero.

### *Conclusioni*

I risultati riportati hanno significative implicazioni nella valutazione terapeutica, e nella definizione dei fattori di rischio, per indirizzare, promuovere ed offrire un adeguato sostegno socio-psicologico alle future madri in difficoltà.

### Valutazione delle temperature timpaniche e rettali nella stima dell'ora del decesso in incidenti in acque fredde.

#### *Introduzione ed obiettivi*

La corretta rilevazione della temperatura profonda del corpo è fondamentale nella stima dell'ora del decesso (SOD) nel nomogramma di Hengge. Lo standard è la misurazione rettale o esofagea. Recentemente però, i termometri timpanici ad infrarossi hanno sostituito, in alcuni casi, lo standard previsto. Come parte del Laboratorio di Psicologia Evoluzionistica Forense, ho assistito come consulente della difesa, un caso di infanticidio materno, dove il Pronto Soccorso ha registrato sul corpo della vittima di due anni, immerso nell'acqua corrente di fiume fredda a 18C°, la temperatura timpanica di 24.9C°. L'ora del decesso stimata tramite termometro timpanico ad infrarossi, è risultata essere la sola evidenza contro la madre nel processo, e sembrava essere in contrasto con molte delle prove tanatologiche e biologiche rilevate (emogas analisi e attività elettrica miocardica). Secondo il profilo psico-biologico, la madre non aveva alcun movente per uccidere la figlia. Pertanto, per verificare la correttezza della SOD, abbiamo studiato la

correlazione tra la temperature rettale e quella timpanica, in caso di ritrovamento di cadavere in acque fredde.

### *Metodi*

Per confrontare le due temperature, sono stati utilizzati 3 ratti da laboratorio, in 3 diverse condizioni: vivo, immerse vivo a 18°C, e immerso, sempre alla medesima temperature, ma deceduto tramite dislocazione cervicale. Per la temperatura timpanica abbiamo utilizzato 3 termometri ad infrarossi, il Genius 3000 A (2 campioni, usato nel caso in oggetto) e il Genius 2 (il più utilizzato nei Pronto Soccorsi italiani). La temperatura rettale è stata registrata tramite una sonda rettale connessa ad un monitor Propaq. Abbiamo inoltre testato l'accuratezza della temperatura timpanica, misurandola sia prima che durante che dopo, su un volontario maschio adulto umano, il cui orecchio è stato esposto per 3 minuti sotto acqua corrente a 18°C e successivamente asciugato.

### *Risultati*

Il Genius 2 ha smesso di registrare la temperatura a 33°C e non è mai ripartito, dopo la prima misurazione sul ratto immerso in acqua. Questa osservazione è stata poi confermata anche dal manuale, che riportava appunto l'incapacità dello strumento di registrare al di sotto dei 33°C. Una volta immersi in acqua movimentata a 18°C la temperatura rettale dei soggetti cominciava a scendere molto lentamente. La temperatura timpanica, registrata tramite Genius 3000°, al contrario, precipita da 34°C a 24°C non appena immersi. Dopo la soppressione, la temperatura rettale continua a scendere senza particolari variazioni, mentre la temperatura timpanica si arresta fluttuando poco al di sopra della temperatura dell'acqua. La temperatura timpanica del volontario umano, dopo l'esposizione all'acqua fredda, precipita sotto i 19°C, mentre la temperatura corporea rimane invariata intorno ai 36.5°C. La temperatura timpanica è ritornata a misurare la corretta temperatura basale dopo 33 minuti dall'esposizione.

### *Conclusioni*

In incidenti avvenuti in acque fredde, come nel caso degli annegamenti, il termometro timpanico ad infrarossi risulta essere un metodo non corretto per misurare la temperatura corporea profonda. Questa in accuratezza può portare a decisioni mediche imprecise, e le conclusioni di questo lavoro suggeriscono che la temperatura timpanica non venga utilizzata in casi come questi. Inoltre, l'utilizzo del Genius 2, è sconsigliato nei Pronto Soccorsi, specialmente in casi di ipotermia data la sua incapacità di registrare temperature inferiori ai 33 C°.

### Errori, Linee guida e suggerimenti: cosa succede nella pratica?

#### *Introduzione ed obiettivi*

I risultati dello studio precedente hanno lasciato aperte diverse questioni. La diagnosi dell'epoca della morte, conosciuta come tanatologia, è un campo multidisciplinare, che include la patologia forense, la biologia, la chimica, la fisica e addirittura l'entomologia forense. Infatti, la SOD è un punto fondamentale nella pratica forense: permette agli investigatori di fare luce sulle ultime ore di vita della vittima, chiarisce le cause della morte, e soprattutto, permette di confermare gli alibi dei sospettati. Tuttavia, prima di diventare una scena del crimine, un luogo in cui viene ritrovato un corpo esanime, è prima di tutto un posto in cui qualcuno ha bisogno di assistenza medica, e questo può interferire con la corretta ricostruzione dell'ora della morte. Ho quindi osservato cosa succede nella pratica medico legale nel nostro Paese.

#### *Metodi*

Sono state analizzate le Linee Guida europee per la rianimazione in condizioni estreme, come l'ipotermia o l'annegamento in acqua fredde, con particolare attenzione a quelle



che sono le norme per la stima della temperatura profonda, sia nel caso della rianimazione sia nel calcolo dell'ora del decesso. E' stato analizzata la procedura nei Pronti Soccorsi e nei dipartimenti di medicina legale. Questi risultati sono stati trovati nei vari website degli ospedali dei nostri paesi, e 9 dipartimenti sono stati direttamente contattati per avere le informazioni richieste. Infine sono stati osservati alcuni casi rilevanti dove l'investigazione della scena del crimine e la stima dell'ora del decesso erano fondamentali per la soluzione dei casi.

### *Risultati*

Le linee guida Europee per la rianimazioni sono molto precise per quello che riguarda il trattamento di pazienti affetti da ipotermia o annegamento. Ma non sono state altrettanto specifiche per quello che riguarda l'uso dei termometri nei casi di annegamento. Nella pratica forense, la metodologia per stimare l'ora del decesso è eterogenea. In Italia le linee guida sono fornite solo a livello locale e addirittura non è obbligatorio avere un termometro per la misurazione della temperatura all'interno dell'ambulanza.

### *Conclusioni*

I risultati mostrano che errori procedurali e la mancanza di norme univoche portano a risultati controversi nei procedimenti penali. Si suggerisce quindi la necessità di ulteriori studi nello studio delle tecniche per la stima dell'ora del decesso ed è necessario un training adeguato per i team di ricerca e pronto soccorso, con l'obiettivo di fornire le migliori cure possibili e preservare importanti prove come la temperatura per la stima dell'ora del decesso.

### Conclusioni Generali

In questa testi ho esplorato le applicazioni della psicologia evoluzionistica nella pratica forense, sottolineando il ruolo dello psicologo investigativo. I risultati della ricerca

hanno implicazioni sia teoretiche che pratiche. Prima è stato descritto e per la prima volta il modello della sexual presence, applicabile allo studio delle parafilie e del comportamento violento tramite realtà virtuale. Poi è stato evidenziato come il neonaticidio materno nella nostra specie abbia una causa evuzionistica, e di come il profiling della madre neonaticida si differenzi da quello della madre infanticida e figlicida. Questi risultati hanno effetti rilevanti sia nella fase investigative sia nella fase di definizione della pena e del trattamento, ma soprattutto nella realizzazione di misure preventive rivolte alle future madri a rischio. Infine, collaborando come consulente in un caso di sospetto infanticidio materno, è stato trovato che la temperatura timpanica, usata spesso nella pratica, non sia una misura utilizzabile per stimare l'ora del decesso in condizioni estreme, dove la temperatura profonda è essenziale. Alla luce di questi risultati, sono state riportate le linee guida per migliorare l'intervento dei medici legali e dei team di rianimazione sul posto, nel nostro paese.

Questi studi hanno dimostrato la versatilità e il valore pratico della psicologia evuzionistica nelle scienze forense. Infatti il risultato più importante di questa tesi è stato dimostrato come le tecniche e le teorie apprese durante questi anni di dottorato abbiano importanti applicazioni nella clinica, nella criminologia e nella pratica forense, e di come possa essere importante proseguire le ricerche nella psicologia evuzionistica forense, a causa delle sue rilevanti implicazioni sociali.

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I dedicate this work to all the amazing people I have lost in these years, but also to the one who will bring new light to my world, Cecilia.

## GENERAL INTRODUCTION

### *The roots of evolutionary forensic psychology*

Evolutionary psychology is a branch of psychology, it has its roots in Charles Darwin's theory of evolution by natural and sexual selection. It focuses on the study of the psychological adaptations of humans to the changing physical and social environment, especially on the transformation in brain structure, cognitive mechanisms, and behavioral differences among individuals (Barkow, Cosmides, Tooby, 1992).

Evolutionary psychology, like evolutionary theory in general, aims for a synthetic theory that includes both rigorous and unbiased observations of human behaviour, counting an examination of the contexts within which behaviours occur, and an explanation of the underlying causes of those behaviors from the perspective of evolutionary biology. As this, it constitutes a unified theory of human behavior, grounded in direct observation, and applicable also to many of the most abstract levels of human cognition (Buss, 2004).

In this view, the mind is a set of information-processing apparatus that were designed by natural selection to solve adaptive problems faced by our hunter-gatherer ancestors.(Tooby and Cosmides, 1992) According to this, human behavior can be explained by internal psychological mechanisms, which are themselves adaptations – the results of natural selection which helped our ancestors to survive and reproduce in ancient times. The adaptationist approach used by evolutionary psychologists uses knowledge of recurrent ancestral problems to generate hypotheses about the functions and forms of cognitive mechanisms in human minds (Duntely, 2001).

This way of thinking about the brain, mind, and behavior is changing how scientists approach old topics, and opening up new ones (Tooby and Cosmides, 1989).

It also provides a very practical set of experimental and observational techniques that allows us to make predictions about human behavior in specific contexts. As an example evolutionary psychology's theories have come from observations of people in partially or fully controlled environments, the same kinds of observations made by social psychologists and sociologists, although from a rather different perspective. Other concepts have come from answers to questions posed during interviews or on questionnaires, or have come from analysis of census data or demographic data collected for other aims (Buss, 2004).

The findings and theories of Evolutionary Psychology have found applications in various fields such as politics, law, literature, Psychiatry and economics. One of the most important applications of evolutionary psychology theories and tools, is in the forensic field. In fact, in the last two decades, a new discipline is widespread, due to its important contribution to the study of violent behavior, namely evolutionary forensic psychology.

As already explained, evolutionary psychology uses an adaptationist approach to explore the cognitive foundations of behaviour (Duntley, 2001). Over the history of humankind, individuals faced particular recurrent problems, that conditioned how long they survived and how successful they were at reproducing. Some individuals had characteristics that made them able to solve better these problems than others, which means that the better problem- solvers were more likely to survive and, especially, reproduce. The adaptationist approach used by evolutionary psychologists uses knowledge of recurrent ancestral problems to generate hypotheses about the functions and forms of cognitive mechanisms in human minds. Our minds address a large reserve of specialized cognitive adaptations that coordinate patterns of behavior

capable of solving that kind of problems (Tooby and De Vore, 1987). For instance, there would have been significant selection pressure for the evolution of strategies to overtake others in contexts of conflict over insufficient resources including competition for attractive mates and territories (Buss & Shackelford, 1997). Numerous sources of contention between individuals have been recurrent over human evolutionary history. One of the most important aim of evolutionary psychology is understanding the nature of these violent antagonistic behaviors in our evolutionary past, because that can let us understand the form and function of manifest conflicts between people in our days, e.g, conflict on mating resource or material resource, as violent strategies to outcompete rivals (as raping, violence or homicide) (Duntley and Shackelford, 2001).

The specific branch of evolutionary psychology, which aims to explain and analyze violent human behavior, using an adaptive perspective, it is called evolutionary forensic psychology. Evolutionary forensic psychology recognizes that crimes such as murder, violence, rape, theft, and cheating are manifestations of evolutionarily recurrent conflicts between individuals. The cost-inflicting strategies that we recognize as crimes may have been favored by natural selection when they gave individuals an advantage in competition for resources (Duntely and Shackelford, 2001; Duntley and Buss, 2005).

This discipline offers a set of means for exploring the functions of psychological mechanisms, it suggests novel hypotheses problems, and provides a logical framework that opens and unites data sources not usually used in psychological research (e.g., comparative, ethnographic, socio-biological profiling). Evolutionary forensic psychology identifies that crimes such as violence, murder, rape, theft, and cheating are manifestations of evolutionarily recurrent conflicts between individuals. The cost-inflicting strategies that is been identified as crimes may have been favoured by natural

selection when gave individuals an advantage in competition for resources (Buss and Duntley, 2006).

Evolutionary forensic psychology is a useful and valuable discipline, applicable to different field of criminology, forensic medicine and law. First because his firm theoretical base, rooted in evolutionary theories, provide powerful set of explanatory tools which can be used to integrate existing knowledge about the aetiology of criminal and victim behaviors (Ellis and Walsh, 1997). Then, this discipline proves to be useful in identifying meaningful categories of criminal behavior, starting with the identification of ancestrally recurrent problems of survival and reproduction, which provided the selection pressured for the evolution of violent adaptations to solve them (Thorhill and Palmer, 2000; Buss, 2005). In fact, different behaviors have different nature and outcomes, as rape and homicide, and their functions in different contexts may be basically distinct.

Evolutionary forensic psychology proves to be valuable in specifying how psychological adaptations acting to produce both criminal behavior and victim behavior, suggested by Daly and Wilson (1988). In the light of that, this discipline is essential in the study of victimology, inasmuch can lead researcher to new insights into the psychology of the victims of the crime. Evolutionary forensic psychology considers the role of co-evolutionary shaping of the psychologies underlying criminal behavior and victim response evolved (Duntley, 2005). This discipline, basically, offers a set of means for exploring the functions of psychological mechanisms, it suggests novel hypotheses problems, and provides a logical framework that opens and unites data sources not usually used in psychological research (e.g., comparative, ethnographic, socio-biological profiling).

For all these reason, evolutionary forensic psychology proves itself to be effective and valuable in forensic context, both in the investigative process and during criminal proceedings. As a matter of fact, evolutionary forensic psychology theories, methods and techniques, satisfying all the *Daubert Standard* criteria, a U.S Supreme Court sentence which determining the standard for admitting expert witnesses testimony in court (Bernstein, 2008). Assuming that judges and lawyers need scientific experts to evaluate both evidences and suspects or defendants, their depositions have to satisfy several criteria that lay down the quality of scientificity. First, scientific expert testimony has to be relevant to the case and reliably to the facts at hand. Then, the testimony has to be the product of sound scientific methodology derived from the scientific method, as the process of formulating hypotheses and then conducting experiments to prove or falsify the hypothesis, and provided a set of "general observations" that it considered relevant for establishing the "validity" of scientific testimony. For example, the scientific expert observations have to be based on empirical tested (falsifiable), subjected to peer review, should refer to the theory and technique which are generally accepted by a relevant scientific community. Further, to establish the validity of the scientific testimony should be considered the known or potential error a the existence and maintenance of standards and controls concerning its operation (Giannelli and Imwinkelried, 2007). In the light of these criteria, evolutionary forensic psychology lends itself to be a valuable support both during police investigations and in the analysis of criminal behavior in court.

My three years-PhD research comes within this theoretical framework, that allowed me to explore the causes of maternal violent behavior, but also to collaborate, as investigative psychologist, in a case of suspected maternal infanticide and to enlighten



procedural mistakes during investigation and during criminal trial in Italy. Moreover, evolutionary psychology proved to be a valuable tool in the study of the concept of "*presence*", a cognitive construct entailed in the diagnosis, through virtual reality, of paraphilias and sexual violent behaviour. More particularly, my thesis is composed by five research. The first study presented here as been conducted in Montréal, Canada, at the Institute Philippe-Pinel, under the supervision of Prof. Patrice Renaud, during my internship period abroad. It consists of a theoretical paper, in which I have analyzed the concept of "presence", as the cognitive and physical feeling to be immersed in a virtual reality ambient, from an evolutionary perspective, outlining the features of a special kind of presence, the "sexual presence" (this chapter has been submitted as theoretical paper in *New Ideas in Psychology Journal*). This theoretical concept finds its applications in the study of paedophilia and sexual assaulters behavior with virtual reality and, at the present, is being tested at Philippe-Pinel Institute, by Patrice Renaud's research team. The second study here presented, has set the aim to test the evolutionary hypothesis on maternal infanticide in an Italian sample. It is composed by two studies, the first aimed to profile and spot the socio-biological difference in the mothers who kill their children, using cluster analysis (this chapter has been published few months ago, as original paper in *Child Abuse and Neglect*). The second one's aim, in the light of the results of the first study, was to find the risk factors of the neonaticide for "reproductive disinvestment", a specific and well-defined kind of maternal reproductive strategies. As a consequence of the experience gained in the laboratory of evolutionary forensic psychology, I attended as a consultant, in collaboration with Prof. Camperio Ciani, a case of suspect maternal infanticide by drowning. The investigation process (described in Fontanesi, 2009), enlighten some procedural inconsistencies made by the coroner who conducted the autopsy and the rescue team who recovered the body of the little

victim. We made an empirical experiment to test the validity of the time of death, estimated with Henssge Nomogram, which pointed out the procedural mistakes and contributed to dropped the charges of murder from the mother (this chapter has been submitted in Journal of Legal Medicine). In the light of these findings, I conducted the last study of my research, which aimed to identify the guidelines in the field of hypothermia and drowning, and to enlighten, throw a short survey, the procedures and eventually, the mistakes, made in our country by medico legal examiners and rescue teams

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## CHAPTER 1 The Sexual Presence Model

### *Abstract*

*Presence* is a phenomenon widely studied by different scientific disciplines and which can be defined as the feeling to be immersed in a reality generated by a range of simulation and immersive technologies, like virtual reality and its derivatives. In the present paper we explore a particular variety of this feeling, namely the *sexual presence*, using evolutionary psychology as theoretical framework. We first emphasize differences between women and men, in sexual imagery and in sexual behavior; then we translate these differences into a *sexual presence model*, bringing out *proto*, *core* and *extended sexual presence* as conceptual layers explaining the phenomenon. Our aim is to give an evolutionary interpretation of sexual presence, in the light of recent findings, and provide some new ideas for future studies, especially in the field of forensic psychology and psychiatry.

### *The concept of Presence*

In the last twenty years, authors from different scientific avenues contributed to the definition of *presence* (Loomis 1992, Heeter, 1992; Riva, 2011; Sheridan, 1992; Slater, Usoh, and Steed, 1994; Steuer, 1992;; Zahorik and Jenison, 1998; Marsh, Wright and Smith, 2001). Presence, as a psychological state akin to perceptual illusion, is to be understood as the interplay between an observer and a technological medium channeling the senses of the former in an immersive fashion. The immersive effect of a particular immersive experience is measured by the feeling of presence, which is

defined as a psychological state or subjective perception causing an individual to give in to the illusions created by a computerized system. This illusion consists in forgetting both the external environment and the immersive technology hardware in favor of the simulated virtual contents (ISPR, 2012; Sadowski & Stanney, 2002; Witmer & Singer, 1998). Presence is therefore derived from perceptions as a result of perceptual-motor determinants, which tie the subjective perspective to a limited set of possible viewpoints (Renaud et al., 2007b, 2010b, 2011). These determinants are most likely mediated by emotional states and biological predispositions (Bouchard, St-Jacques, Robillard & Renaud, 2008; Renaud, Bouchard & Proulx, 2002; Bouchard et al., 2012; Renaud et al., 2002a; Renaud et al., 2007a; Renaud, Chartier & Albert, 2009b; Schubert, Friedman & Regenbrecht, 1999). Presence as a psychological phenomenon, share commonalities with other cognitive processes which control the individual actions in different contexts (Riva, 2011; Lee 2004b, Riva, Davide, Isselstei, 2003).

Despite that presence appears to be a rather modern phenomenon involving complex new media, by 15,000 B.C.E. Cro-Magnon man had already evolved with a brain capable to create and experience complex visual representations, especially with cave paintings. The caves of Lascaux, in France, for example, demonstrate that our ancestors were creating representations of reality, in which they took components of the actual world to recombine them in an interactive multisensory experience. These paintings (mostly representing animal hunt, shamanists or magical figures, and sexual scenes), which were experienced as reality itself by spectators, were lit up by flickering oil lamps bringing to the foreground vivid illusory percepts. This must have added to the sense that painters and spectators were immersed in a world apart, in a sort of multisensory, totalizing experience that engaged sight, sound, smell, and touch as one of the first conscious virtualization of the physical world (Heim, 1995; Mioduser, 2005).

The same level of identification happened with sexual and religious rituals, from hunting and fighting paintings and representations, up to the catharsis in Greek tragedies: being a part of the scene, sharing feelings and emotions, individuals could learn from those situations, and replicate them in real life (Malinowski, 1929; Bennett, 1981; Stone, 1995; Groenen, 2000). All these events were made to stimulate participation and emulation: an increased feeling of presence could help maintain attentional engagement in the illusion inducing display therefore favoring the development of cognitive states to be translated in *real* actions (Bell, 2009; Pagel, 2012).

As human experience in general, the feeling of presence, has been studied from two different but complimentary perspectives, the volitional and the cognitive (Leontjev, 1978, 1981; Pacherie 2006, 2008). In this sense, Riva et al. (2011) consider presence as a neuropsychological construction which is the product of both *volitive* and *cognitive* processes; according to this author presence is “*an intuitive perception of successfully transforming intentions into enaction*” (Riva et al. 2011). For Riva and colleagues, presence is one single feeling, which can be disentangled following three different sub-processes, the latter being defined as steps of a complex and mostly unconscious form of supervising of actions and experience. Presence would be deeply related to our goals and to all the actions and operations we make to achieve them. *Proto presence*, is an unconscious process, involving body movements and motor intentions of which we are not aware (Riva et al, 2009, Riva et al., 2011). *Core presence* is a conscious process that primes the intended action, to then sustain and guide it in monitoring its effects in the present moment. *Extended presence* is related to the consciousness of future intentions; it involves emotional and cognitive aspects and feeling about the Self’s future expectations (Riva et al., 2011). These three levels of presence are deeply connected to

the evolution of the Self (Damasio, 1999), that is to the consciousness of the continuity of ourselves across different contexts. In this paper we will provide a tentative new point of view about a special kind of presence, the *sexual presence*. The concept of *sexual presence* was first introduced by Lombard and Jones (2004), describing the particular psychological, cognitive and physical feelings generated by pornography, i.e. by watching others having sex through special media. This narrow view of sexual presence can be extended to the experience of sexuality through immersive means, either as spectator or actor. It is worthy to note that observing others having sex must have been, a very common activity in our plio-pleistocenic environment.

Nowadays sexual media contents are consumed by millions of people every day around the world, and the first purpose of “adult entertainment industry” (papers, internet, pictures etc.) is to make the individual feeling psychologically and physically involved in the content. This phenomenon becomes more evident if we think about present cyber-sex, erotic chat-line, or erotic telephone-lines (Lombard and Jones, 2004).

***A new feature: Sexual Presence and differences between men and women, from an evolutionary perspective***

One of the main topics of evolutionary psychology studies concerns the intersexual differences and the evolution of mating systems, which is strictly connected to *sexual presence*. Even if for both sexes the goal of sexual behavior is reproduction, it comes with different features: as it has been shown in almost all the species, and according to Darwin’s sexual selection theory, there is a sex that chose (female) and a sex that is chosen (males), (Darwin, 1859/1911; Trivers, 1985; Wilson, 1997).

Inter-sexual differences should be considered when one wants to induce sexual presence. A particular attention to the individual’s sexual fantasies, which are the mirror

of individual sexual desires, should be given. Sexual fantasies drives sexual behavior, have evolved over time and are the most common form of sexual experience. They can be aroused by something that we have seen, read or heard, they can be generated internally or externally both (Jones and Barlow, 1990; Wilson, 1978, 1987, 1997; Ellis and Simpson, 1990; Hicks and Leitenberg, 2001; Yost and Zurbriggen 2006). Sexual fantasies are a clear example of the differences in the development of male and female sexuality in our species.

According to Wilson (1987, 1997), these erotic thoughts can be sexually explicit (in men) or rich of emotions (in women). So we can state that the term *sexual fantasy* refers to almost any mental image that is sexually arousing for an individual and on which he should have control (Leitenberg and Henning, 1995). First, a considerable number of studies have shown that men differ from women in the quantity of fantasies. Men have more sexual thoughts than women, and they get more easily and more often aroused by them (Knoth et al., 1988, Jonas and Barlow, 1990; Daskoch, 1995). Specifically, men usually have more fantasies than women during masturbation, but not during the sexual intercourse (Hessellund, 1976; Mednick, 1977; Knafo and Jaffe 1984). However, the main difference lies in sexual fantasies' content. According to the literature, men's fantasies involve multiples and unknown partners, while females fantasies usually involve well known partners, like men that they have met, and it's also uncommon for women dreaming about group sex (Arndt et al, 1985; Hunt, 1974, Barclay, 1973; Kelley, 1985; Pelletier and Herold, 1998; Jones and Barlow 1990; Ellis and Symons, 1990; Hicks and Leitenberg, 2001). Furthermore, women's fantasies involve descriptions of the context and feelings related to the sexual intercourse (Wilson and Lang, 1981; Knoth et al., 1981), On the contrary, men's fantasies involve a large number of visual contents, sexual details and genitals images (Follingstad and Kimbrell,



1986; Smith and Over, 1991; Janssen et al., 2003). Women, more than men, imagine themselves in a passive role during the sexual intercourse while men see themselves in an active and dominating role (Barclay, 1973; Iwawaki and Wilson, 1983, Knafo and Jaffe, 1984; Mednick, 1977, Halderman et al., 1985; Yost and Zurbriggen, 2006). Sexual fantasies about being forced to sex are common in both sexes, but they seems more frequent in women than in men (Knafo and Jaffe, 1984; Mednick, 1977; Arndt et al., 1985; Sue 1979; Davidson and Hoffman, 1986; Pelletier and Herold, 1988; Critelli and Bivona, 2008, Hawley, 2009). Fantasies about forcing someone to have sex are also common to both sexes, but more in men (Sue, 1979: Arndt et al., 1985; Crepault and Couture; 1980; Greendlinger and Byrne, 1987; Hald and Malamuth, 2008). Sexual fantasies are basic and very resilient behaviors, in this regard it is interesting to observe that even male to female transexuals when screened for sexual fantasies have been shown to remain typically male in terms of sexual fantasies' quantity, variety of partners, explicit details and so on (Camperio Ciani et al. 2011). Over the years, evolutionary psychology studies gave several explanations about the differences in sexual fantasies. Firstly, our male ancestors had a higher reproductive potential than women and not having any obligation in terms of parental investment, they could increase their reproductive success mating with many females. So sexual selection has favored males with a low threshold of sexual arousal which find attractive each new fertile female encountered. Men, in fact, have a rapid sexual arousal response to visual stimuli, they just *need a look* to understand if a woman has good genes (beauty and youngness) and is fertile (Symons, 1979). Furthermore, a large number of partners means more chances to reproduction (Ellis and Symons, 1990, Eagly, 1999; Hicks and Leitenberg, 2001, Pound et al., 2002; Pound 2002). For what concern rape and forced sexual fantasies, which are more common in men, several authors suggest that it is

because of *sperm competition* (Thornhill and Gangestad, 1996; Pound et al., 2002; Goetz and Shackelford, 2006; Shackelford, 2007; Goetz et al., 2008). Still according to evolutionary theories, women would determine the value of a potential partner on the basis of physical and psychological features, the latter indicating the presence of good genes, or signals of being able to reach economic and political success, or again, of a sincere interest in investing in a relationship. A slow sexual arousal protects women from engaging in random sex with everyone (Symons, 1979). Furthermore, the nature of male sexual arousal to signs of female fertility, like the waist to hip ratio or developed breast (this process is well-known from the companies of pornography), is in steep contrast with the well-known reluctance of women to engage in impersonal sexual intercourse. This process would have meant that men look at women as an object of desire and perceive the intercourse as women granting (e.g some women live the sex as a “concession” to men) As a result, women have undergone selective pressure toward a perception of themselves in this role and a tendency to manipulate the desire of males in their favor. Nevertheless, some studies reveal that there is a percentage of women who imagine themselves as victims of forced sex and rape, a type of sexual fantasy that is correlated with higher level of promiscuity and an open-mind regarding sexuality (Strassberg and Lockerd, 1998; Critelli and Bivona, 2008).

All of these differences persist also in the using of pornography. Men consume significantly more pornography than women, and they are more attracted to hardcore pornography, i.e. pornography with poor or no affective relationship context and emotional attachment. In general, men (also gay men and lesbian, according to Albright, 2008) are more psychologically aroused by pornography (Hald, 2006). In confirmation of what we have already said, men more than women seem to prefer pornography with many different actors as compared to pornography with the same

actors performing different acts (Malamuth, Mosher and MacIan, Træen, Spitznogle, and Beverfjord, 2004). As a consequence, straight women are less interested in pornography and if exposed to pornography from their partners, they reveal lowered body image evaluation, and they seem to have a partner who's critical of their body and increases pressure to perform acts seen in pornographic films; and the same happens also in erotophilic women (Malamuth, 1996). Even if cyberspace mating seems to be devoid from most of the "real life" cultural and social pressures (Cooper, 1999), according to Dawson and McIntosh (2006), when individuals are seeking for mates online, men put emphasis on their own wealth and attractiveness, while women stress their physical attributes, despite of other positive psychological characteristics.

### ***Proto, core and extended sexual presence in men and women***

How we can identify *proto, core, and extended* sexual presence? In the light of what has been said so far, we should suppose that these three steps are different for men and women.

Sexual presence, as a feeling of being emotional, physically and psychologically aroused by simulated sexual stimuli, is strictly related to sexual arousal and sexual behavior. According to Janssen (2011) sexual arousal is an emotional and motivational condition, concerning several components, from genital response to sexual desire, which suppose to lead individuals to engage in sexual behavior.

Even if this construct is still under investigation by psychological and medical research community, a large number of studies, during the years has tried to develop a sexual arousal model, in order to identify and recognized what sexual arousal is, and his components (like Janssen, 2011; Sachs, 2007; Singer 1984; Wiegel et al., 2007, Barlow

1986). Despite of this, everyone seems to agree that female sexual arousal model is different from the male one. And, at least for men, one of the main indicators of sexual arousal is represented by penile erection (even if not always it can be seen as a *real* display of excitement, Gordon and Carey, 1995; Chivers et al. 2010).

Consistent with these, we tried to identify *proto*, *core* and *extended* sexual presence in sexual behavior, using two of the main sexual behavior paradigms in literature.

In 1984, Singer presented a three stage-model of the process of sexual arousal, which can be used to describe *sexual presence* in man. The first, *aesthetic response* is an affective reaction to an attractive figure, that produces an increase in interest toward the object of attraction. This process involving eye and head movements toward the object, and we can say that this process involves both cognitive and volitional aspects. The main goal, rather adaptive, is to get closer to the person of interest and, maybe have a sexual intercourse with her. So we can say that this first stage can be described as the *proto presence*. *Approach response*, the second step, a direct consequence of the first, involves bodily movement toward the goal, and an increasing of attention. This step, can be referred to the *core presence*. The last steps, is the *genital response*, a physical reaction the closer proximity to the object, which is mostly unconscious and uncontrollable, like *proto presence*, too. *Proto presence*, is seen as unconscious aesthetic and genital response, which is related to the feedback sent by the object of interest, in a loop, which leads to sexual arousal (at the genital level).

*Extended presence* in males, in a sexual context, can be related with strengthen own self esteem, appearing as a powerful, strong and healthy male.

As previously explained, females and males sexualities are really different to each other, and identifying the same links in women is more difficult.

Even in this case, we can hypothesize that *aesthetic response*, corresponding to the orienting phase of the sexual arousal (the moment where the subject notice the object, and start to “*feel*” something), is linked to *proto presence*. *Core presence* is related *approach response* and, in this case, also to *genital response*. The sexual arousal (psychological, and physical) in this case, is due to the relation with the object, and is not only a consequence of visual stimuli, as it happens in males. The third part of Riva’s theory, *extended presence*, the conscious feeling which is beyond the sexual behavior, is not easy to identify in Singer’s theory.

According to the “Sexual Behavior Sequence” (Byrne, 1977; Fisher, 1986), in fact, sexual behavior is the outcome of a process which involves cognitive, affective and physical aspects. Sexual behavior is the result of evolved response tendencies, cultural patterns and social structure: external conditioned and unconditioned erotic stimuli prompting imaginative, affective and physical responses and, if the internal system of evaluations/expectations is satisfied, the outcome is the sexual behavior (Fisher, 1986). In women, for example, *extended presence* can be seen as a *maternity desire*, so their main goal is to find an appropriate man which satisfied all of their expectations. Showing physical attractiveness, dating and knowing someone, get emotionally close to another individual can be seen as *core presence*, and the sexual intercourse as the *proto presence*. According to this, to elicit or generate sexual presence in women, seems to be more complicated than in men, because not always sexual arousal overlaps genital response (Rupp and Wallen, 2008).

### ***Proto core and extended presence in sexual offender***

According to Ward and Beech's 2006 "Integrated Theory of Sexual Offender" (ITSO), sexual assault is the result of three casual factors that interact to each other in an ongoing: biological factors (as genetic factors, brain development), proximal and distal factor of the ecological niche (like personal circumstance, social and cultural environment), and neuropsychological processes associated to brains structures (motivation/emotional system, action selection and control, perception and memory) (see for more Ward and Beech, 2006). Sexual presence seems to linked to this third point. According to ITSO theory, sexual offenders defect in the motivational and emotional system, they get confused in emotionally charged interpersonal situations, showing an incapacity to understand others feeling. This malfunctioning can drive sexual offenders to act in a violent way toward the object of interest. Furthermore, sexual offenders show a malfunction in the actions control, that generate impulsive behavior, and they fail to inhibit negative emotions. We can define these processes as deviant *core presence*, as an inability to consciously starting, control and monitoring their actions. So the outcome of their approach to the object of sexual interest (as *approach response* in Singer's 1984 theory), will be negative, where the sexual offender violently force the victim to sex (deviant *proto presence*).

The last neuropsychological system individuated by Ward and Beech (2006), is associated with hyppocampal informations and posterior neocortex. Malfunctions in this systems generate maladaptive believes, problematical interpretations of social encounters, and cognitive distortion of the relationship. Moreover, sexual offenders which show these symptoms fail to regulate sexual desire, as a consequence of deviant sexual fantasies that precede it. Literature has shown those child molesters, serial reapers, and other paraphilic sexual assaulters, starting having deviant fantasies early in

adolescence, and drives their sexual offending behavior (Abel et al., 1987; Marshall and Eccles, 1991). Wald and Beech (2006) suggested that this occurs when individuals have dysfunctional scheme and is related to the incapacity to ménage attachment issues and mood problems, associated to a failure to regulate sexual desire and properly drive sexual interests. This process is related to an abnormal *extended presence*, where the sexual offender fails to see himself in a future adequate sexual and emotional relationship.

This system is in line with evolutionary theories, according which: raping is a conditioned strategy, potentially present in all men, and that is confirmed by the fact that one third of the men reported to have erotic fantasies where they forced women to sex (McKibbin, 2008; Hall, Shondrick, & Lalumière & Quinsey, 1996; Thornhill& Thornhill, 1992). From an evolutionary point of view, there are several type of sexual offender (See Lalumière & Quinsey, 1996, for more details): disadvantage men (men who don't have access to women, because of a low social status and lack of social skills according to Kalichman et al., 1998; Thornhill & Thornhill, 1983, Lalumière, Chalmers, Quinsey, & Seto, 1996) war rapists, partner rapists (for spermatic competition, Thornhill & Thornhill, 1992 Shackelford and Leblanc, 2002, Shackelford et al., 2005) and specialized rapists (serial rapists).

**Tab. 1** Comparison between Riva and colleagues (2011) presence theory and male, female and sexual offenders sexual presence

| <b>Presence</b>                | <b>Explanation</b>                      | <b>Sexual Presence Men</b>   | <b>Sexual presence in women</b>                                | <b>Deviant Sexual Presence (sexual offenders)</b>                                   |
|--------------------------------|---|--|--|---|
| Proto Presence - unconscious   | Motor Intentions                        | <i>Aesthetic/genital response</i>  | <i>Psychological and sexual arousal and sexual intercourse</i> | <i>Violence</i>   |
| Core Presence - conscious      | Sustains, guides and monitoring actions | <i>Approach response</i>   | <i>Dating, get emotionally close</i>                           | <i>Inability to control and monitoring actions</i>                                  |
| Extendend Presence - conscious | Feeling about self future expectations  | <i>Breeding, Self esteem, appear more healthy , powerful and strong (repr)</i> | <i>maternity</i>   | <i>fails to see himself in a future adequate sexual and emotional relationship.</i> |

***Sexual presence and virtual reality***

According to this interpretation of current data, men and women sexual attitudes and behavior should be really different, and all of these differences have to be taken in account when we want to induce and maximize the effects of sexual presence, in a virtual reality context. *Sexual presence* (when it is based on sexual fantasies) should be measurably dimorphic (Symons, 1979) and particularly resilient of change. It has been already demonstrated that virtual reality is a powerful tool to assess sexual fantasies and interests in individuals (Renaud et al., 2004; Renaud, Goyette et. al., 2011), especially with child molesters. Riva and colleagues (2011), have developed an interesting model about how to maximize the feeling of presence in experimental contexts. In first place, (1) is necessary to recognize the real purpose of the user, to facilitate his experience and increase the level of presence. Then (2) the developer has to include in the mediated



experience all the virtual and physical products that influence human actions in everyday life, to support his experience inside the virtual reality system and to facilitate the feeling of presence. Every action should have different sublevels, and every level specific goal, beginning and ending. To induce a realistic perceptual illusion and a highest possible level of presence, (3) the developer should to identify all the steps and the layers, and provide the adequate and complete visual stimuli to support the user actions. It follows that (4) *proto presence* is easier to get than *core presence*. To get the highest level of presence, which integrates operations, spatial and sensory presence, the user needs as much identifications as possible inside the virtual system, which should be provide by the developer, through a convincing and controlled motor and perceptual illusion (Riva, 2011).

As an example, when we want to induce *sexual presence*, we should be aware that visual sexual stimuli are not enough to induce the highest level of presence, at least with women, in the light of intersexual differences discussed before. We should consider that there is a set of memories (idiosyncratic sexual stimuli, Renaud et al., 2010) and experience that influences our sexual set of fantasies and, as a consequence, our behavior (Knafo e Jaffe, 1984; Pelletier e Herold, 1988). In this case, the erotic imagery features of the user have to be identified, to develop a virtual environment which is significant to the participant, and give him/her the feeling or perception of sexual presence, and induce sexual arousal. Again, to maximize the presence feeling, the developer has to consider that in almost all the cultures, sexual behaviors and intersexual relationship are regulated by social and cultural rules, which usually prevent the free (and sometimes, offensive) expression of individuals natural dispositions and desires (Symons, 1979; Wilson, 1997; Ellis and Symons, 1990; Fishet et al., 2012). Under this circumstance, we can mention for instance, how inducing sexual presence

with VR could be an efficient tool to assess and tests theories among deviating behaviors, such as like raping or pedophilic actions. Several studies has shown, in fact, that is sufficient to be immersed with virtual characters depicting relevant sexual features (in this case, children), to induce a significant sexual excitement in child molesters, measured using circumferential penile plethysmography, as a measure of *sexual proto presence* (Renaud et al., 2011).

It would be possible, using virtual reality, to induce maximal sexual presence, and testing for example, in a forensic context, some of the most interesting evolutionary hypothesis on rape Thornhill and Thornhill (2000). According to Thornhill and Thornhill (2000), in fact, men have developed different adaptations, that can explain rape behavior like assessment of the vulnerability of potential victims, a context sensitive trigger that starts violence; a preference for victims in their fertile ages; a larger amount of sperm in the ejaculate during rape than consensual sex; a specific arousal associated with the use of force (violent sexual fantasies), and marital rape in circumstances of “sperm competition (Thornhill and Thornhill, 2000). To verify this, the developer should include in the mediated experience a character of vulnerable young women, which the subject can interact. Then, the developer has to identify a context sensitive trigger (this information can be reached in the subject history), that should guide and push the subject to sexual arousal and react violently against the virtual character. And, to confirm Thornhill and Thornhill hypothesis that sexual offenders release larger amount of sperm in the ejaculate during rape than consensual sex (2000), the researcher has to test level of testosterone in the subject during the experimental session with a control one. Rape and pedophilia are just a few of the several perspectives to use the construct of *sexual presence* in virtual reality to assess deviant behavior for forensic purpose.

### ***Conclusion***

In this paper, we have presented the feeling of *sexual presence*, evolved from the larger concept of presence, under the lens of evolutionary psychology. Most probably, sexual presence is an evolutionary phenomenon, featured by motivational, emotional and physical feelings, that an individual experience when exposed to internal or external stimuli (a.e. sexual fantasies, erotic movies, VR, on-line erotic chat). In order to generate maximal sexual presence, which arises from an adequate combination of form and content, we have identified the differences between men and women in sexual behavior and sexual arousal. While it appears easier to induce sexual presence in men, due to the generally genital response to visual stimuli, which *usually* dovetails to sexual arousal, that doesn't happen in women, where sexual presence seems to be more interrelate to a psychological and emotional involvement in the situation. Our conclusion is that it might be useful to study sexual behavior disease and anomalies, using and developing the concept of sexual presence through virtual reality, particularly in a forensic context.

We hope that our ideas could open new debate on the phenomenon of *sexual presence*, which needs an exhaustive study from more different disciplines.

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## **CHAPTER 2 Mothers Who Kill Their Offspring: Testing Evolutionary**

### **Hypothesis in a 110-cases Italian Sample**

(Camperio Ciani A, Fontanesi L (2012). Mothers who kill their offspring: testing evolutionary hypothesis in 110-case Italian sample,. Child Abuse and Neglect. 36(6):519-527)

#### ***Abstract***

Objectives: This research aimed to identify incidents of mothers in Italy killing their own children and to test an adaptive evolutionary hypothesis to explain their occurrence.

Methods: 110 cases of mothers killing 123 of their own offspring from 1976 to 2010 were analyzed. Each case was classified using 13 dichotomic variables. Descriptive statistics and hierarchical cluster analysis were performed both for cases and variables, and significant differences between clusters were analyzed.

Results: The Italian sample of neonaticides (killings of children within the first day of life) was found to satisfy all evolutionary predictions for an evolved behavioral, emotional and motivational pattern to increase fitness, showing a consistent profile for offending mothers. Relatively young, poor women with no partner kill their offspring non-violently, either directly or through abandonment, and they attempt to conceal the body. These women have no psychopathologies and never attempt suicide after killing their children. All neonaticide cases fall in a single cluster that is distinct from all other offspring killings by mothers. Infanticide (killing of children within the first year of life) and filicide (killing of children after the first year of life) do not significantly differ according to any of the variables measured. The common profile of mothers who have committed infanticide or filicide includes psychopathology, suicide or attempted suicide

after killing their children, violent killing of their victims, and no attempt to conceal the victims' bodies. These results suggest that maternal infanticide and filicide represent an improper functioning of adaptation, and their profile are much more variable than those of neonaticide offenders.

Conclusion: Our study confirms that only neonaticide is an adaptive reproductive disinvestment, possibly evolved in the remote past, to increase the biological fitness of the mother by eliminating an unwanted newborn and saving resources for future offspring born in better conditions. Neonaticide is shown to be clearly distinct from infanticide and filicide and therefore should be approached, prevented, and judged differently.

### ***Introduction***

The killing of a child by his or her biological mother has occurred in our species since its origin (e.g., Moses in The Bible), in every culture and every population (Miller, 1997; Milner, 1998; Sudha & Rajan, 1999; Sahni et al., 2008). The killing of offspring by their mother also occurs under similar conditions in non-human primates (Hausfater & Hrdy, 1984; Hrdy, 1979, 1992, 1999; Sugiyama, 1965), cats (Rudnai, 1973), rodents (Parmigiani, Palanza, Mainardi, & Brain, 1994), and several other species. According to evolutionary theory, the killing of offspring by its mother may, under certain conditions, represent an evolved behavioral pattern that increases the reproductive fitness of the mother (Trivers, 1985).

Mothers may kill their offspring when, for some external reason, pups life expectancy is reduced; under this condition, mothers benefit from interrupting breeding or abandoning the offspring and dedicating her resources to survival and future pregnancies. This adaptive hypothesis for neonaticide has been verified in an array of comparative studies.

In rats, horses, and even monkeys, mothers may kill unwanted offspring after birth, but they are also capable of reabsorbing the fetus before birth when external conditions jeopardize offspring life expectancy (Bruce, 1960; Roberts, Lu, Bergman, & Beehner, 2012).

Evolutionary psychiatry suggests that animal species, including ours, evolved behavioral, emotional and motivational patterns to maximize fitness, defined as the number of an individual's progeny that survive into the next generation (Barkow, Cosmides, & Tooby, 1992; Cartwright, 2000; McGuire & Troisi, 1998; Stevens & Price, 2000). In our species, maternal killing of offspring generates massive distress in the general public due to the seeming contradiction between maternity and violence towards offspring.

Daly and Wilson (1988) have performed seminal research on maternal child killing, and they have delineated the context, modalities, and possible causes of such killings that suggest they may have an adaptive value for mothers. Daly and Wilson (1988) proposed that human mothers have evolved specific behavioral, emotional and motivational patterns that drive them to kill their offspring during the first year of life (infanticide). In cases of offspring killing, mothers are usually very young and hence still have significant reproductive potential, but they are experiencing great economical and/or social difficulties that could jeopardize breeding success. According to these authors, similarly to other animal species, evolutionary forces in a remote past shaped mothers' behavior, emotions, and motivations to interrupt breeding and resume investing in their own survival for future breeding chances under improved socio-economic conditions (Daly & Wilson, 1988).

It was further hypothesized that this homicidal pattern could possibly be mediated through a stress response (Hatters Friedman, McCue Horwitz, & Resnick, 2005).

Various studies on mothers who kill their offspring have generally confirmed such predictions (Harris, Hilton, Rice, & Eke, 2007; Lewis & Bunce, 2003; Overpeck, Brenner, & Trumble, 1998; Stone, Steinmeyer, Dreher, & Krischer, 2005). Most researchers observed, however, that the predictions of Daly and Wilson (1988) fit especially well with maternal killing of children in their first day of life (neonaticide) (Briggs & Cutright, 1994; D'Orban, 1979; Hatters Friedman et al., 2005; Spinelli, 2001).

Mothers may also kill their own children later than at birth, as during their first year of life (infanticide) (Hatters Friedman et al., 2005; Scrimshaw, 1984) and after their first year of life (filicide) (Bourget, Grace, & Whitehurst, 2007; Hatters Friedman et al., 2005). In a relevant number of mothers killing older offspring, psychopathology seems to be implicated (Bourget & Gagné, 2002; Resnick, 1970; Rodenburg, 1971; Spinelli, 2004; Stanton, Simpson, & Wouldes, 2000), while in others, jealousy toward the partner induces the mother to kill her offspring (the Medea Complex) (Liem & Koenraadt, 2008). Other cases might be triggered if the child possesses severe disabilities (altruistic filicide).

### ***Aims***

The still-unanswered question is whether neonaticide, infanticide, and filicide can be objectively distinguished by profiles that might help to prevent them. Further, it is not clear which of these forms of offspring killing represent evolved, adaptive behavioral patterns that increase a mother's reproductive fitness in the long term. Our study aimed to identify incidents of Italian mothers killing their own children and to test an adaptive evolutionary hypothesis to explain their occurrence.



## ***Methods***

Data may be collected on mothers who kill their offspring with epidemiological or psychiatric methods. The epidemiological method generally makes use of national archives and services such as VICLAS (Violent Crime Linkage System) in Canada or VICAP (Violent Criminal Apprehension Program) in the United States. The epidemiological method allows for the collection of large quantities of data that cover a long time span but generally have relatively limited analytical depth (Beyer, Mack, & Shelton, 2008; Bourget & Gagné, 2002; Harris et al., 2007; Overpeck et al., 1998). The psychiatric method consists of sampling individuals in forensic psychiatric hospitals. This method has a more restricted sample size that is partly biased, since it is composed solely of mothers who killed their offspring and who have been diagnosed as psychopathological. However, the psychiatric data collection method has the advantage of offering great analytical depth for every case (Krischer, Stone, Sevecke, & Steinmeyer, 2007; Stone et al., 2005).

In Italy, archives and services that store case information on mothers who kill their offspring, such as VICLAS or VICAP do not yet exist. Police departments and penitentiary archives keep data regarding sentencing and prisoner detention time, but not regarding the type of crime committed by offenders with their profiles. Furthermore, in Italy, even mothers who kill their offspring and are diagnosed with severe psychopathology do not necessarily remain in forensic psychiatric hospitals for long periods; the court sends most of them to therapeutic closed communities after tenure in the forensic psychiatric hospital. In such closed communities, privacy rules prevent anyone from accessing patient files.

We could not perform a complete epidemiological survey of maternal offspring killings due to the lack of adequate archives, but we aimed not to limit our research to

psychiatric hospital surveys. Hence, we opted for a typical criminalist method by starting from the most complete sources of information available, which are the archives of national and regional newspapers. The newspapers were not the source of our data, but rather the starting point for data collection. Once each case was found, all necessary variables for the study were sought and verified in lawyers' archives and eventually in the archives of the Forensic Psychiatric Hospital of Mantova, the only psychiatric hospital in Italy that admits female patients.

Lawyers could allow us to access their archives for all closed cases, following our guarantee of anonymity. A number of cases of mothers sent to closed therapeutic communities had been previously filed in the Forensic Psychiatric Hospital, where we could examine their relevant variables. The Mantova Forensic Psychiatric Hospital has an ongoing collaboration with our Department of General Psychology that allows our researchers to access patient data, provided that they are kept private and anonymous. With the collaboration of lawyers and the Forensic Psychiatric Hospital, 110 complete cases of mothers who had killed 123 children between 1976 and 2010 were collected. Our research program and methods were in accordance with the Declaration of Helsinki and approved by the Ethical Committee of the Department of General Psychology of the University of Padova, Italy.

### ***Limitations***

Using the criminalist method, we were able to cover all categories of cases rather than restricting our study to psychopathological cases. However, we could not cover all maternal offspring killing cases that had occurred; some were too poorly covered, and others were even unreported in the newspapers. By comparing police numerical

statistics of infant killing by mothers, we estimate that our study included approximately one half of all the cases that occurred in the past 34 years.

Some cases are unpublicized because an undetermined number of primarily neonaticides are not noticed or scrutinized by the authorities. Up to 20% of SIDS (sudden infant death syndrome) cases are reckoned to be to unidentified non-natural causes, primarily infanticide, producing a large so-called obscure number (Logan, 1998). Furthermore, we limited the variables collected to rather general socio-demographic data, locations and event descriptions. Our study was limited this way to include non-psychopathological cases; we could not reach the analytical depth of the Forensic Psychiatric Hospital files for all cases, and could not always collect exact psychopathological diagnoses of the mothers.

In some cases (25 of 51 psychopathological diagnoses, reported in Table 1), the diagnoses were assessed but not certified because they derived from public investigation into the life of the mother after the offspring was killed. These investigations were expressed in court, but with no diagnosis from the Forensic Psychiatric Hospital. Despite the intrinsic limitations on our sample size, we believe that our data set, due to stochastic distribution, did not contain fatal systematic sampling errors between cases considered and cases excluded, or concerning factors such as: gravity, context, age of victim, age of mothers, presence or absence of psychopathologies, gender of the victim, and geographical distribution of cases in Italy.

### ***Variables***

We followed the list of variables and their definitions established by Stone et al. (2005) and Krischer et al. (2007), with some minor modification. All variables are dichotomic (yes–no) as follows:

- Young: mothers who kill a newborn are usually younger than others. Following Daly and Wilson (1988) and Stone et al. (2005), we included in this category mothers younger than 25 years old when they gave birth to the victim. This age cut-off is rather conservative because in Italy the average female age at first births at 29 years, comparatively late (ISTAT: Italian Institute for Demographical Research).
- Poverty: Hollingshead (1975) individuated a four-factor index for social status that is frequently used in empiric research to identify economical social status. As we could not follow this classification due to lack of information, we arbitrarily included in this category all women who were declared to be in poor economic conditions, including women who did not have economical support (even from a husband or other family member), women who were unemployed or attended high school, and women who were illegal immigrants with no regular employment. We also included in this category young female students, since high school students in Italy rarely have their own income for use in eventually supporting a child.
- Foreigner: This category included all immigrant mothers who were not yet Italian citizens, most of whom were found also to be illegal.
- Hidden body: Often, women who kill their offspring try to hide the murder, leaving the body in a bag, in a closet or in a garbage bin (Dulit, 2000; Kohm & Liverman, 2002; Lee, Li, Kwong, & So, 2006). Hence, we indicated whether the infant body was hidden.
- No partner: A relevant variable for describing mothers who kill their offspring is the presence or absence of a partner. We included in the “no partner” category single mothers, widows, and divorced women, who did not receive any support from their ex-husband.
- Home: We classified whether the murder happened in the mother’s home.

- Violent killing/suffocating: We recorded whether the behavior that led to the killing was violent. Some mothers kill children with no violence, which includes suffocation with a hand or a cushion on the victim’s mouth and abandonment of the offspring in conditions preventing survival. Other mothers perform killings that we identify as violent murder, which includes stabbing with objects like scissors and knives, shooting, poisoning, drowning, choking with different objects, and beating a child to death. - Other offspring: This variable differentiates cases in which the mother was in her first pregnancy from cases in which the mother had other sons or daughters.
- Suicide: This variable classifies whether the mother attempted suicide or committed suicide. Joint filicide–suicide was included in the sample because our aim was to identify whether there are fitness differences according to the behavior leading to the killing of offspring. Suicide or attempted suicide, in these cases, would not increase the fitness of the mother.
- Psychopathology: In our data set, we could not always identify the nature of psychopathologies that affected mothers who kill their offspring. However, in Table 1, to the extent possible we reported the frequency of different diagnoses in our data set, assessed by the Forensic Psychiatric Hospital archive of Mantova, Italy, the only one in Italy dedicated to females.

**Table 1** Mantova Forensic Psychiatric Hospital Diagnoses in female patients who killed their own offspring.

| Diagnosis                 | Frequency | %    |
|---------------------------|-----------|------|
| Major Depression          | 13        | 11,8 |
| Psychotic Disorder        | 5         | 4,5  |
| Hysterical Disorder       | 1         | 0,9  |
| Schizophrenia             | 2         | 1,8  |
| Depressive psychosis      | 2         | 1,8  |
| Schizo affective disorder | 2         | 1,8  |
| Borderline Disorder       | 1         | 0,9  |
| Unspecified               | 25        | 22,7 |

### *Data analysis*

We first generated a descriptive statistical table comparing neonaticide, infanticide and filicide. We compared these three categories using  $\chi^2$  analysis. We then performed a hierarchical cluster analysis on cases and on all previously listed variables, using squared Euclidian distances for binary data using the Ward method (for a detailed explanation on the effectiveness of this methodology, see Krischer et al., 2007). Cluster analysis is the most adequate method for generating case groupings based on correspondence of relevant variables, rather than on an a priori definition. Hierarchical cluster analysis produce dendograms, both describing clustered cases and variables (Aldenderfer & Blashfield, 1994; Everitt, 1993) The highest-level groups identified by our cluster analysis were then compared using ANOVA, to further examine the relative contributions of the different variables to the cluster solution.

### ***Results***

We found 39 women who killed their children within 24 h after birth (neonaticide sex ratio: male 51%, female 49%); 28 mothers who killed children younger than 1 year of age (infanticide sex ratio: 50% male, 50% female); and 43 mothers who killed older children (filicide, sex ratio 51% male, 49% female). No victim sex bias was found for all cases of mothers killing offspring in Italy. In Table 2, the cases of neonaticide, infanticide, and filicide are classified according to the age class of the mother. This table shows that neonaticidal mothers are most strongly represented in the youngest age class, though 18 cases correspond to older mothers.

**Table 2.** Age class distribution of all mothers who killed their offspring

| Age group | neonaticide | infanticide | filicide | Total |
|-----------|-------------|-------------|----------|-------|
| 14-25     | 21          | 1           | 0        | 22    |
| 26-35     | 12          | 20          | 17       | 49    |
| 36-45     | 6           | 6           | 23       | 35    |
| >45       | 0           | 1           | 3        | 4     |
| Total     | 39          | 28          | 43       | 110   |

Table 3 further illustrates that neonaticidal mothers are, on average, significantly younger than both infanticidal and filicidal mothers. There is also a significant difference between the age of mothers who commit infanticide and those who commit filicide, but if we control for the age of the victim (age of the mother minus age of the victim), this difference fades. Hence, age of the mother at birth does not significantly predict infanticide or filicide.

**Table 3** Mean age of the mother killing own child comparison

|                                   | Age of the mother at the time of the homicide |             | Age of the mother at the birth of the victim |             |
|-----------------------------------|---|-------------|--|-------------|
|                                   | mean  | s.d.        | mean   | s.d.        |
| <i>Infanticide</i>                | 32.3  | 5.3         | 31.5   | 5.4         |
| <i>Filicide</i>                   | 36.3  | 5.0         | 30.3   | 4.8         |
| <i>Neonaticide</i>                | 26.5  | 7.5         | 26.5   | 7.5         |
|                                   | <b>t</b>                                      | <b>p</b>    | <b>t</b>                                     | <b>p</b>    |
| <i>Infanticide VS Neonaticide</i> | -3.47   | <b>.001</b> | -2.95  | <b>.004</b> |
| <i>Filicide VS Neonaticide</i>    | -6.92   | <b>.000</b> | -2.69  | <b>.009</b> |
| <i>Filicide VS Infanticide</i>    | 3.14  | <b>.002</b> | .97  | .335        |

We further observed that that Foreign mothers who commit neonaticide are older than non Foreign mothers (Foreign mother's mean age 28.8, s.d. 8.2, non Foreign mean age 24.8, s.d. 6.5) and more frequently have other offspring (Foreign 5 cases out of 17, non Foreign 3 cases out of 22).

**Table 4.**  $\chi^2$  analysis of differences in all variables considered

| Variables       | Neonaticide VS Infanticide |       | Neonaticide VS Filicide |       | Filicide VS Infanticide |      |
|-----------------|----------------------------|-------|-------------------------|-------|-------------------------|------|
|                 | $\chi^2$                   | p     | $\chi^2$                | p     | $\chi^2$                | p    |
| Suffocating     | 64.041                     | <0.01 | 41.996                  | <0.01 | 3.160                   | .075 |
| Suicide         | 30.775                     | <0.01 | 20.361                  | <0.01 | 1.139                   | .286 |
| Poverty         | 42.265                     | <0.01 | 36.710                  | <0.01 | 1.640                   | .247 |
| Hidden Body     | 35.993                     | <0.01 | 26.461                  | <0.01 | .380                    | .845 |
| No partner      | 41.498                     | <0.01 | 41.466                  | <0.01 | .806                    | .369 |
| Young           | 31.125                     | <0.01 | 18.679                  | <0.01 | 1.558                   | .212 |
| Home            | 1.747                      | .186  | .810                    | .368  | .101                    | .750 |
| Foreigner       | 17.419                     | <0.01 | 10.657                  | <0.01 | .198                    | .656 |
| Violent Killing | 64.041                     | <0.01 | 41.996                  | <0.01 | 3.160                   | .075 |
| Psychopathology | 42.875                     | <0.01 | 27.239                  | <0.01 | 1.301                   | .254 |
| Other offspring | 8.281                      | <0.01 | .189                    | .664  | 4.804                   | .028 |

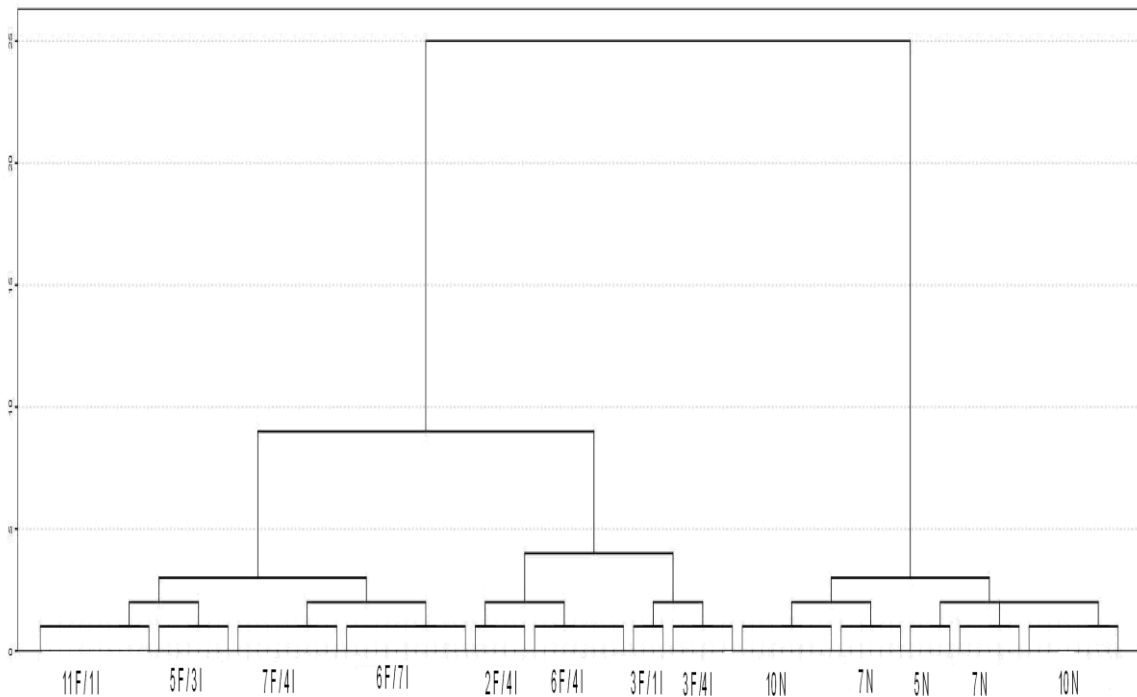
Table 4 presents pairwise comparisons of all classes of maternal child killings, and it shows the significant differences between them according to recorded variables, excluding the age of the victim. Neonaticide was significantly different from infanticide and from filicide for all socio-demographic variables, except the location of the killing



and the presence of other offspring. No variable significantly differed between filicide with infanticide.

Fig. 1 shows a hierarchical cluster analysis of the cases. Due to spatial constraints, cases that did not differ for any of our measured variables are all represented in the same final cluster. The cluster analysis highlights two large clusters, one including all and only neonaticides (N) and one including filicides (F) and infanticides (I), which always cluster together at any level (the number preceding each letter indicates how many individual cases are grouped in each final cluster). No single cluster includes only filicides or only infanticides; hence, cluster analysis fails to distinguish at any possible level between infanticide and filicide in our data set.

**Fig. 1.** Cluster analysis of cases using Euclidean average distance method Ward.



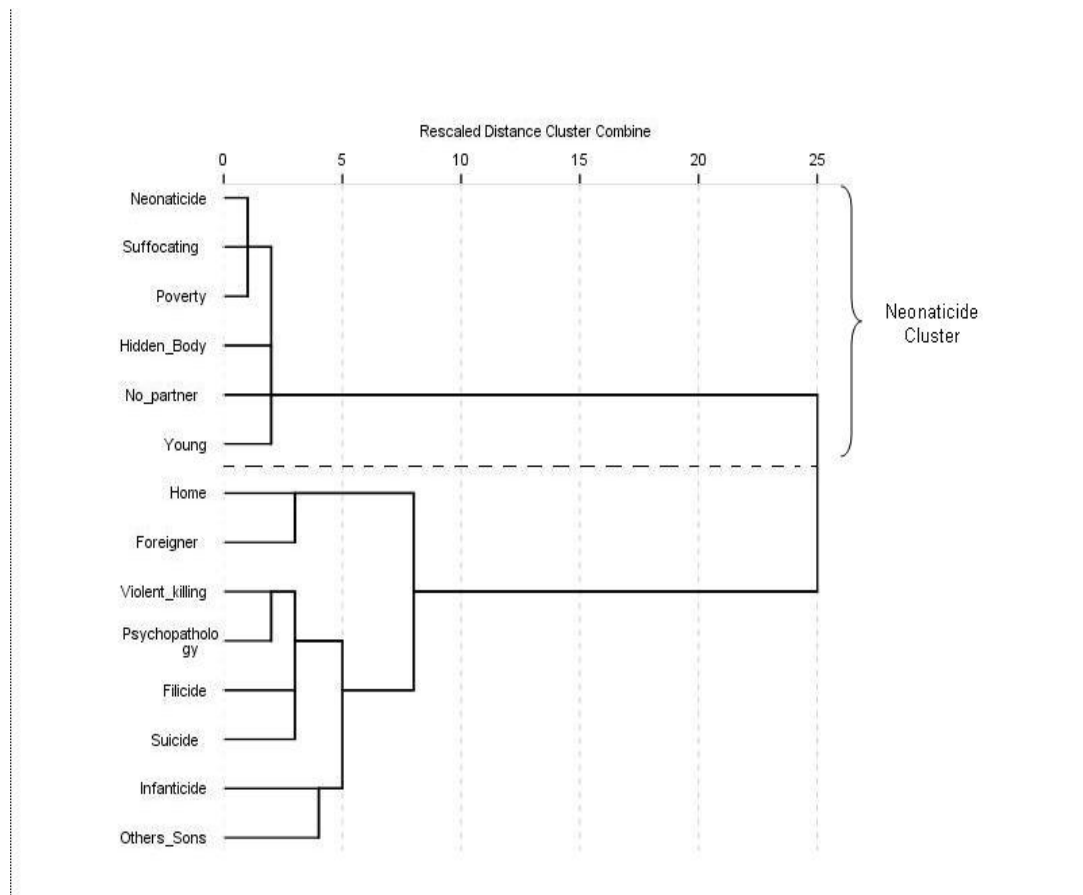
**Table 5.** ANOVA for first level clusters produced in the cluster analysis of cases using the Euclidean average distance Ward method

|                  | <b>Neonaticide Cluster 1</b> | <b>Filicide, Infanticide Cluster 2</b> | F      | p     |
|------------------|------------------------------|--|--------|-------|
| Partner          | 4 (10,5%)                    | 60 (83,3%)                             | 104,8  | <,001 |
| Hidden body      | 29 (76,3%)                   | 7 (9,7%)                               | 90,3   | <,001 |
| Home             | 34 (89,5%)                   | 58 (80,6%)                             | 1,4    | ,233  |
| Young            | 21 (55,3%)                   | 1 (1,4%)                               | 75,1   | <,001 |
| Neonaticide      | 39 (100%)                    | 0 (0%)                                 | 1305,8 | <,001 |
| Violent killing  | 5 (13,2%)                    | 69 (95,8%)                             | 254,4  | <,001 |
| Other sons       | 7 (21,2%)                    | 30 (46,2%)                             | 6,01   | ,016  |
| Psychopatologies | 2 (5,3%)                     | 51 (70,8%)                             | 68,8   | <,001 |
| Suicide          | 0 (0%)                       | 33 (45,8%)                             | 33,03  | <,001 |
| Foreigner        | 17 (44,7%)                   | 4 (5,6%)                               | 31,3   | <,001 |
| Poverty          | 28 (74,4%)                   | 31 (28,2%)                             | 66,8   | <,001 |
| Suffocating      | 33 (86,8%)                   | 3 (4,2%)                               | 254    | <,001 |

The ANOVA in Table 5 confirms the significant difference between the whole neonaticide cluster and the infanti-cide/filicide cluster for all variables except the presence of other offspring ( $p = 0.016$ ) and for whether the crime occurred at home ( $p = 0.233$ ). Fig. 2 illustrates that in the variable cluster analysis, the neonaticide cluster collects the following variables: suffocating, poverty, hidden body, no-partner, and young age of the mother. Again, filicide and infanticide fail to segregate into different clusters, even at the variable analysis level. One cluster gathers domestic location and foreign nationality of the mother.

Another gathers filicide with suicide, psychopathology, and violent killing. The last cluster associates infanticide with having other sons.

**Fig. 2.** Cluster analysis of variables using the Euclidean average distance Ward method.



### ***Discussion***

The risk of a child being killed by its own biological mother is highest in the first 24 h (neonaticide), and significantly more so if the mother is young, has no other children and is in critical social and economical conditions. The mothers who commit neonaticide are generally young and significantly younger than infanticidal or filicidal mothers. Controlling for the age of the victim, infanticidal and filicidal mothers do not differ in age, implying that infanticidal and filicidal women all became mothers at comparable ages. The risk of a child being killed rapidly decreases as its age increases (Daly & Wilson, 1988).

In our sample across 34 years, filicide has the lowest frequency (43 cases across 15 possible years of the victim). Infanticide (28 cases across a single year of the victim) and neonaticide had the highest frequencies (39 cases across only the first day of life of the victim). The relative higher frequency of neonaticides compared to other children killings confirms the notion that during the first 24 h of life, a child is by far most at risk of being killed, specifically due to actions by its own biological mother (Daly & Wilson, 1988; Hatters Friedman et al., 2005; Sykora, 2000). The neonaticide behavioral, emotional and motivational profile confirms previous studies on reproductive disinvestment and evolutionary predictions (Camperio Ciani & Chiarurcci, 1995; Daly & Wilson, 1988; Overpeck et al., 1998; Stone et al., 2005).

Neonaticide in our data set is associated with young mothers who possess residual reproductive potential, are eco-nomically fragile, and hide the body after the murder. In extreme cases, the neonaticide is concealed further by the denial of pregnancy, even to the mother herself (Beyer et al., 2008; Bonnet, 1993; Hatters Friedman & Resnick, 2009; Meyer & Oberman, 2001; Miller, 2003). The commonly observed attempt to hide the victim's body after neonaticide suggests that the mother is enacting a strategy to survive and to avoid the negative and potentially harmful social reaction against the killing of her child: in other words, the mother is enacting a coping strategy. This rarely happens in cases of filicide or infanticide, in which no effort is made to conceal the events after the killing. We confirm the results of Liem and Koenraad (2008) which indicate that neonaticide is never followed by suicide of the mother (Liem & Koenraad, 2008), nor is the neonaticidal mother particularly affected by psychopathologies (Stone et al., 2005).

In our neonaticidal mothers, the murder occurs more often via lack of assistance or abandonment than by violent killing, indicative of an individual fighting between her own maternal instinct and the necessity to reproductively disinvest (Hrdy, 1992).

This framework confirms the evolutionary prediction that neonaticidal mothers are trying to cope with unwanted off-spring, so they may survive and eventually reproduce again in more favorable conditions (McGuire & Troisi, 1998; Trivers, 1985). Our study confirms that there is a recurrent profile of a mother who kills an unwanted newborn: she is young, poor, and fragile, as described by Daly and Wilson (1988).

It has been noted that most neonaticidal mothers are very young and have no other offspring (Daly & Wilson, 1988; Overpeck et al., 1998; Stone et al., 2005; Sykora, 2000). From an evolutionary perspective, the question that arises is why young mothers giving birth for the first time in extreme ecological conditions may have increased their fitness through neonaticide. A possible adaptive answer could be the inverse relationship between the mother age at first birth and her age at the subsequent birth. A woman who delivers her first child too early in life, especially if she is in difficult economic and social conditions, severely reduces the frequency of future pregnancies, her total fecundity, and therefore her fitness. Longitudinal sociological studies by Ellison (2003) and Ellison and Hall (2002) showed that couples with low economic status who reproduced very early in life have in fact produced fewer offspring in their lifetimes compared to couples who reproduced later in life and had better social and economic resources (Ellison, 2003; Ellison & Hall, 2002). However, a particularity of our sample that holds some social relevance is that the neonaticide cluster does not differ from the others with respect to presence of other offspring, and the average age of neonaticidal mothers is young, but not as young as other studies have indicated (Hatters Friedman et al., 2005). A possible explanation is that in the last 20 years Italy has seen

considerable illegal immigration of foreign women, especially from non-EU eastern countries. These women left their native countries and, usually their families, including children, to work as housekeepers, nurses and temporary elderly caregivers. In our sample the illegal immigrant mothers who have committed neonaticides were not necessarily young or previously childless, and apparently acted without regard to their residual reproductive potential. Often in these precarious conditions, an illegal immigrant woman who has a newborn would lose her job and housing, thus drastically reducing support for her previous offspring. The Italian case, which we do not believe to be isolated in light of new migratory patterns, suggests that it is not young age per se, or first offspring per se that might induce the neonaticidal behavioral, emotional and motivational pattern, but rather a more general survival risk affecting either past or future offspring. It is the overall risk to one's own reproductive success that triggers the neonaticidal strategy, precisely as predicted by an evolutionary adaptive hypothesis (e.g., Trivers, 1985).

The infanticide and filicide cluster, on the contrary, does not show a corresponding adaptive pattern, suggesting that neonaticide is a rather different phenomenon from both infanticide and filicide. We confirm the conclusions of Stone et al. (2005), who suggested that filicide and infanticide are mostly committed by psychopathological mothers, and psychopathological mothers kill their offspring following schemes that are not predicted by evolutionary theory (Stone et al., 2005) but instead represent improper functioning of otherwise beneficial adaptations. Such killings are often followed by suicide or attempted suicide, the offending mothers are older, and their profiles are very variable (Harris et al., 2007; Stanton et al., 2000). Krischer et al. (2007), using data from a psychiatric hospital, found significant differences in behavioral patterns between infanticide and filicide. In our study, however, the cluster

analysis of cases could not split filicide from infanticide, and as can be seen, all clusters group filicide cases with infanticide cases. There was not a single variable that distinguished infanticide from filicide, other than the age of the victim. A possible reason why our data differ from those of Krischer et al. (2007) is that our sample is broader-spectrum, rather than remaining restricted to a forensic psychiatric hospital sample, which might have overemphasized the role of psychopathologies in infanticide and filicide and underestimated the role of suicide.

With our data and variables, we could not isolate in any specific cluster either Medea Complex filicide or altruistic filicide from others. In agreement with Stone et al.'s results (2005), our cases of infanticide and filicide do not fit specific evolutionary adaptive predictions, but rather point to improper functioning of adaptations. We observed a general lack of a recurrent profile in these latter types of child murder by mothers, as previously observed by Hatters Friedman and Resnick (2007). The most common profile we observed is that infanticide and filicide were conducted by psychopathological mothers who tended to commit, or attempt, suicide and did not try to hide the body of the victim afterwards.

### ***Social implications***

Evolutionary psychology provides hypotheses for understanding the origin and adaptive value of human behavior, even behavior as socially unacceptable and horrible as the killing of a child by its own mother. This approach attempts to understand the adaptive role of behavior and the evolutionary forces that might have shaped it during our long Plio-pleistocenic socio-ecological phase (e.g., Barkow et al., 1992; Buss, 1999). A question arises regarding the possible utility of studies addressing the adaptive value of

a nevertheless atrocious behavior. The answer is that if a behavior can be shown to have an adaptive evolutionary origin, rather than to be a pathology or a “sin,” then the possible solution for dealing with such behavior could be radically different. A pathology can be pharmacologically treated, but an evolved behavioral pattern cannot. An evolved behavior, however, can be controlled, and its circumstances can be predicted, since they occur only in specific environmental situations, while pathologies produce mostly unpredictable behaviors. Hence, directing attention to characteristic socio-ecological conditions could be helpful for predicting and preventing socially dangerous adaptive behaviors.

Neonaticide appeared to be the most common form of homicide by mothers in Italy. Camperio Ciani and Chiarurcci (1995) suggested that neonaticide could be defined as a form of late abortion. They defined neonaticide as an adaptive reproductive disinvestment. When abortion was not readily available for most of our evolutionary past, adverse external conditions, when present, could manifest after a woman has already become pregnant. Similarly to voluntary abortion, neonaticide might be planned well ahead of birth, but it could be conducted only immediately after birth (Camperio Ciani, 2009; Camperio Ciani & Chiarurcci, 1995). For example, it has been shown that the introduction of laws that legalize abortion reduced neonaticide in Slovakia (Sykora, 2000) and reduce SIDS (sudden infant death Syndrome) in many western countries (Hrdy, 1999). Considering that neonaticidal mothers conceal their pregnancies even from themselves, alerting general practitioners to monitor pregnancies in young, poor women might not be sufficient to prevent neonaticide, as in the case for illegal abortion. In Italy, some regions are experimenting with social services that monitor young pregnant women, but this is not sufficient to prevent neonaticide entirely. An effective form of prevention is to promote public dissemination of information about maternity



disclaimers and the release of unwanted children for immediate adoption (Bonnet, 1993). This possibility is available in Italy, but it is insufficiently promoted by hospitals and medical centers. Our present research shows that the risk factors for neonaticide include not only young age and absence of previous offspring, but also the socio-economic fragile conditions that most illegal immigrant women face at any age. The lack of information about of maternity disclaimers and release of children for immediate adoption, the limited access to social services by immigrant women, fear and shame, are all factors that jeopardize the effectiveness of the present neonaticide preventive strategy and deserve further reflection. Italy has long applied an indulgent criminal jurisdiction towards neonaticidal mothers, recognizing the miserable social and economic situations that induce them to commit such a crime. Prison sentences are typically reduced from 20 years (homicide) to 4 years (neonaticide) (art. 578, Italian Penal Code). This legal indulgence is insufficient if not coupled with a system for preventing the causes of neonaticide.

Even more challenging is to prevent infanticide and filicide, driven by psychopathologies. Because infanticide and filicide represent the improper functioning of adaptive mechanisms rather the proper functioning of an evolved adaptation, their prevention is far more complicated, if not impossible. Their prevention is left to the professional sensibility of general practitioners and psychiatrists, who must identify individual risk factors and psychopathologies (such as mood disorders) that might induce mothers to such extreme acts against their own offspring.

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## **CHAPTER 3 Why mothers kill newborn: a focus on Italian sample**

### *Abstract*

Neonaticide is a special kind of infanticide, committed in the very first hours after the birth, always by mothers. Several authors claim that this behavior is caused by psychopathology. In our work, according to evolutionary psychology theories, we suggest, instead, that this behavior has a biological origin. We analyzed 35 cases of neonaticide in Italy, from 1976 to 2006, and we find out recurrent variables in order to identify risk factors, and build neonaticide mother profile. To compare possible risk factors, all data have been normalized, based on the actual frequency of the reference populations, in order to have more adequate values, estimated on the population characteristics. The first result of this research is that the woman single and in poor socio-economical condition, who can't raise her offspring and could not have an abortion, might kill her newborn, following a conscious strategy of "comprehensive reproductive instinct" rather than following the "maternal instinct". These women, usually young, poor, without a partner, decide to not invest their energies in the nurture of a child in the present, preserving energies for future pregnancies. Immigrated single mothers have a risk factor for neonaticide ten times higher than Italian woman. The women who commit neonaticide in our sample are not affected by psychopathology, and do not commit suicide, as it happens in other parental infanticide, are normally at their first birth and are usually very young with a great residual reproductive potential. These conclusions might have implications both in juridical assessment, related to the



punishment, and therapeutic assessment, as the identification of risk factors, and to offer and promote adequate socio-psychological support to at risk future mothers.

### ***Introduction***

Neonaticide is a special kind of infanticide, committed within the first twenty four hours from the birth, usually by victim owns mother. The Italian Juridical System consider neonaticide as a crime committed under difficult life circumstances and under the thrust of emotive pressures, affecting mothers after childbirth.

Several authors observed that usually neonaticides are committed by young, single and poor mothers (Neresian et al. 1985; Briggs et al. 1994; Friedman, et al. 2005), usually affected by psychopathology, like post-partum depression, maternity blues and, less frequently, puerperal psychosis (Nivoli, 2002; Spinelli 2004; Reece, 1991; Monhan, 2002).

According to evolutionary psychology, psychopathology cannot explain the adaptive reason that leads a mother to kill her newborn, and suggests an impressive theory to explicate why a single, poor and too young mother decide to do that (Trivers, 1985; Hausfather and Hrdy, 1984; Daly and Wilson, 1988; Hrdy, 1999; Buss, 1999).

Trivers in 1985, explained that in many animal species, infanticide allows individuals to increase the access to resources, for themselves and for their offspring, to the detriment of others offspring. In the light of this theory, it is possible to analyze the apparently maladaptive behavior of maternal neonaticide. Hilda Bruce (1960) discovered that female rodents are able to block their pregnancies following exposure to the scent of an unfamiliar male, in order to avoid the risk of neonaticide by the new male, the waste of resources and be available for a new copulation. The same process has been noted also

in horses and in other mammals. The pregnancy block could be a female's post-reproductive strategy. Females, according to this interpretation, are more likely to seek proximity to dominant males, in order to increase their chance to reproduce with an alpha male carrying good genes and better resources (Schwagmeyer, 1979).

Similar behavior is well known also in several species of felines and primates. Young mothers leave their offspring in the very first moment after birth, if find themselves in situations that are not conducive to rearing cubs, owing to food shortages or lack of shelter (Hrdy, 1992). In this case, maternal neonaticide can be defined as "reproductive disinvestment". As an example, young lionesses attack and kill their cubs at the birth, in order to save their own energies for a future pregnancy, because they probably would not survive to the breeding if they had to pay the costs of nurture, and as a consequence, their offspring would die too.

According to several authors, this behavior has common adaptive genetic bases with the offspring killing behavior in our species. In fact, Daly and Wilson (1988), gave a biological explanation for the maternal neonaticide in humans. According to these authors, parental psychology has been shaped by natural selection, ensuring that individuals take adaptive decisions, even if extreme (*where adaptive means useful to increase reproductive success or fitness*), based on the resources availability for the offspring survival (Daly and Wilson, 1988). Consistently with this theory, investing or disinvesting in an offspring, depend on the relative costs or benefits, as parental resources are a limited source of energy. In line with this hypothesis, Sycora (2000) suggested that the very first day after birth could be the most dangerous day in a child life, enough to be considered as the day in entire life with the highest probability of being killed, and almost exclusively by each own biological mother.

Same psycho-biological motivations can be seen also in women who decide to interrupt their pregnancy. According to Camperio Ciani and Chiarucci (2005), in our species, the smaller the proto-genetic interval becomes, the greater inter-genetic interval become: in other words, the earlier is the first pregnancy of a woman, more time elapses before the next one, as to effect the entire woman's reproductive life. Single and young mothers, have usually no economical support, and this situation could disproportionately increase the cost of the cares at the expense of future pregnancies. In an evolutionary perspective, giving up on a pregnancy in difficult conditions might then be a part of a female reproductive strategy, in order to achieve the largest number of children in better conditions in the future, and, on the contrary, does not mean to go against maternal instinct (Trivers, 1972). The mother, in this case, is not affected by psychopathology, but she acts under the pressure of her "*reproductive comprehensive instinct*" immediately after the childbirth. Under this circumstance, this behavior could be dictated by an essential biological and understandable motive. This might be an act by individuals who are planning their future reproductive destiny.

The "*reproductive comprehensive instinct*" hypothesis, according which, under certain difficult conditions, a mother kills her newborn, clearly comes up against common beliefs that a sane mother should protect her child at any cost, following her positive "maternal instinct", that distinguish our specie from the others (Merzagora, 2003).

The predictions which would confirm this alternative adaptive hypothesis are 1) mothers who commit neonaticide don't kill themselves after the aggression, 2) they don't show any signs of psychopathology, 3) they are always in difficult situations 4) usually are single, young and poor (e.g. illegal immigrants, unemployed) and 5) they have a high reproductive potential residual (they can have other sons in the future).

Otherwise, if the “loss of maternal instinct” due to psychopathology is true (Merzagora, 2003), neonaticidal mothers should display 1) psychopathology symptoms and signs, beyond the violent behavior, 2) attempting suicide after the aggression, as it happens frequently in other infanticide and filicide 3) and the distributions of these psychopathological mothers should not be correlated with 4) young age 5) reproductive potential residual 6) socio-economical condition.

### ***Aims***

Here we analyzed the profiles of 35 neonaticidal women, from 1976 to 2006, in order to verifying the psycho-biological causes of neonaticide, and comparing profiles of women who kill their newborns with women who decide to interrupt their pregnancy, in order to identify risk factors and contribute to the prevention of this phenomena.

### ***Methods***

To see the cases recruitment see chapter 2 pag. 65. Nevertheless, in Castiglione delle Stiviere Forensic Psychiatric Hospital (Mantova, Italy) archives there were no neonaticidal case. The neonaticidal database was composed of 35 cases of neonaticide, classified on the bases of the following variables.

- Mothers age
- Mothers Nationality (Foreigner or Italian)
- Residence
- Mothers marital Status
- Modus Operandi
- Place of the aggression
- Presence of diagnosed psychopathology

- Suicide/Attempted suicide
- Socio-economical status

*Statistical Analysis*

To analyze possible risk factors all data have been normalized, based on the actual frequency of the reference populations, in order to have more reliable values, according to ISTAT 2002. We used the following equation to establish the risk factor of neonaticide distribution in our Country ( r )regional, and ( i ) immigrant)

$$Fr = \frac{(Nt/nA) \cdot (NR/NT)}{PT \cdot (PR/PT)}$$

Where:

NT= Total number of infanticide

nA= Years observed

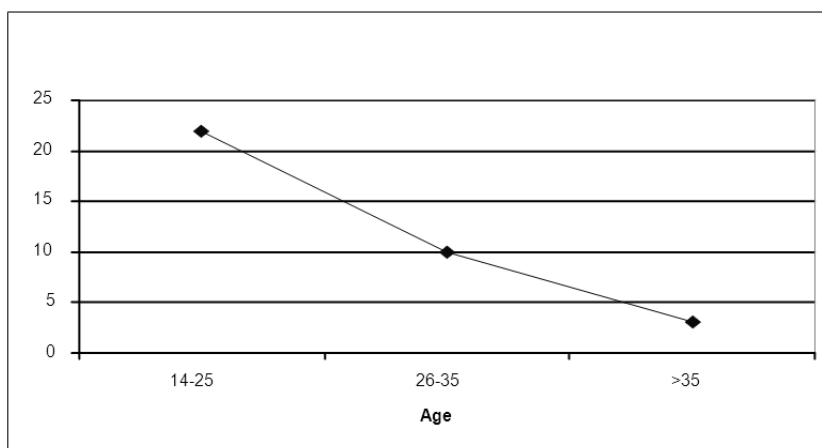
NR= Number of neonaticide per Region

PT= Total Population of mothers who carried their pregnancy to end (ISTAT, 2002)

PR= Population of mothers who carried their pregnancy to end per Region in one year (ISTAT, 2002).

**Results**

**Fig. 1** Neonaticidal mothers age



**Fig.2** Terminated pregnancies and completed by age of the mother. (ISTAT, 2002)

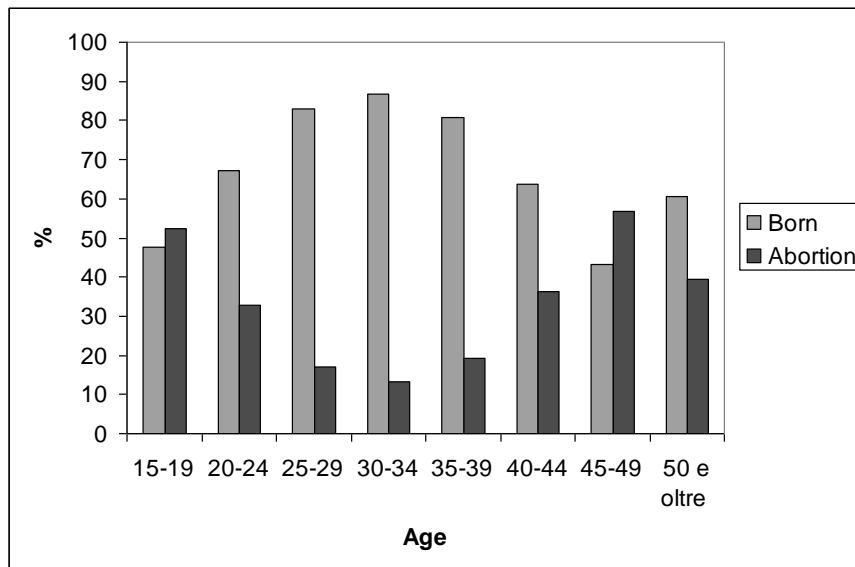
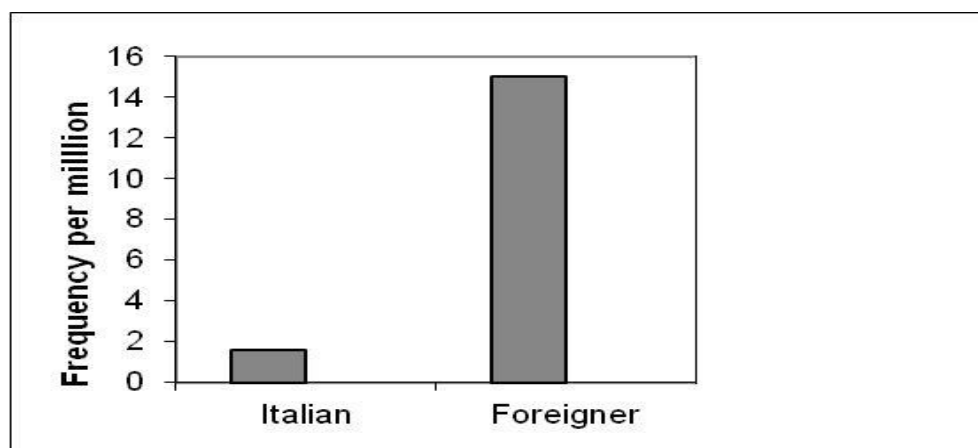


Fig.1 shows that 66% of neonaticidal mothers has less than 25 years old. In our database, age range is from 14 to 40 years old (M= 25.4, sd= 6.581)

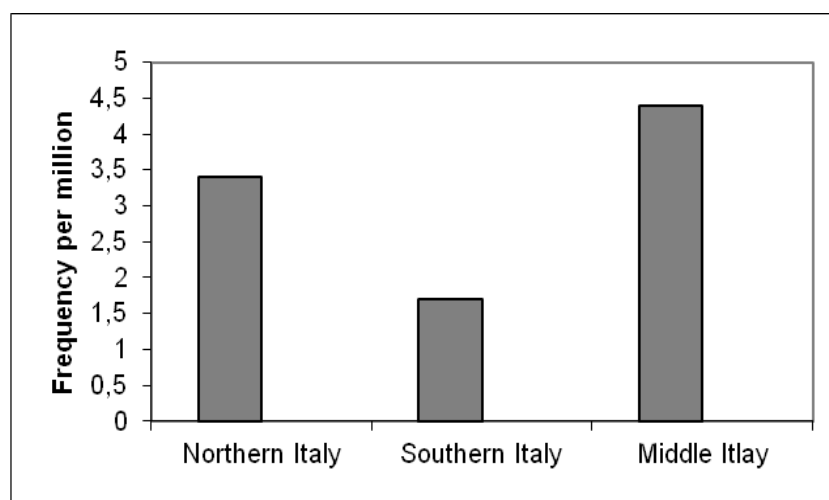
The first-time mothers in our sample are 32 out of 35 (expected value on an average fecundity of 1.9 (N= 35,  $\chi^2 = 12.57$ , df=1,  $p > .01$ ).

**Fig. 3** Frequency per million of neonaticide every 30 years, in Italy, per nationality



In the neonaticidal sample, 60% of mothers is Italian, while 40% is of foreign nationality (especially from Eastern Europe). Considering that the reference Italian female population consisted of 13,255,207, and the not- Italian was of 933,091, the frequency for millions of neonaticide is 1.58 for Italian women, and 15.0 for foreigners women, every 30 years (fig.3), which means that that the probability to kill the newborn, immediately after birth is 10 times highly for immigrant women.

**Fig. 4** Frequency per million of neonaticide every year, in Italy, per residence (northern Italy, Southern Italy, Middle Italy)



49% of neonaticidal mothers comes from Northern Italy, 31% from Central Italy and 20% from Southern Italy. Fig.4 shows the frequency per million of neonaticide every year, in Italy, per residence.

Most of the mothers in our sample was unmarried, 3 out of 35 were married, but their husbands didn't live in Italy, where the aggressions took place and only one was divorced.

**Fig. 5** Neonaticidal mothers modus operandi

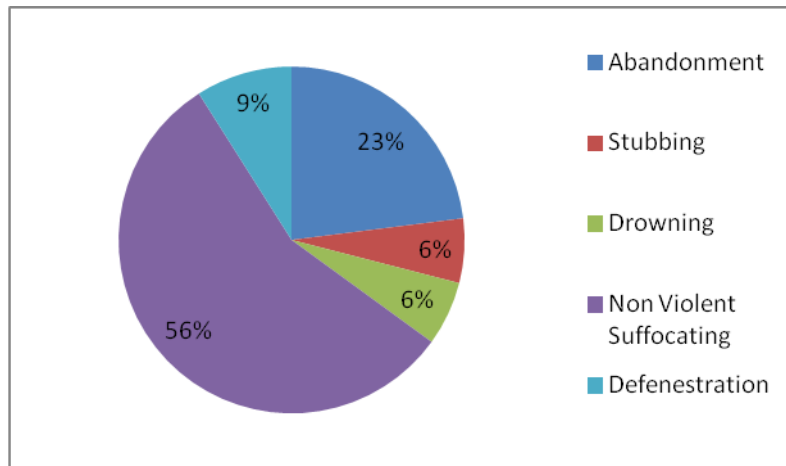


Figure 5 shows neonaticidal mothers modus operandi. Most of them suffocated their newborns in a non-violent way, using a pillow or plugging the baby's mouth with their hand. For what concerned the socio-economical status, we have analyzed the occupation of these women: 79% of the sample was unemployed, 11.4% had an undeclared work (as old men caregiver) and 8.6% was housewife.

In 57% of the cases, mothers, after aggressions, hid babies bodies in bags or boxes inside wardrobe or in similar, small, places. This fact suggests that both birth and aggression occurred inside mothers houses without any help from other people. In 8 cases out of 35, bodies were founded in outdoor rubbish bins.

No one of the mothers in our sample committed or attempted suicide, and none of the mothers in the sample had a psychiatric diagnosis. In only one case, the woman was drug addicted.

### ***Discussion***

These results suggest a strong homology with what have been observed in other animals. The literature suggests that reproductive disinvestment has an adaptive value, in fact, female kill their offspring when they are in difficult situations, where the breeding would have a high cost, jeopardizing future pregnancies. In the light of this,



the killing of the newborns represents a reproductive strategy, which allows neonaticidal mothers to have future pregnancies in better conditions. These potential neonaticidal mothers have spread from generation to generation, among the population, as they have left more offspring than those which, in critical situations, gave birth to their children, endangering their survival.

The profiling of neonaticidal woman is strongly different from the infanticidal and filicidal ones (Camperio Ciani and Fontanesi, 2012). These women are young (under 25 years old, on average), they kill in the very first hour after the birth and usually are at their first pregnancy, with an higher potential reproductive residual, also they are single women, with no partner to support them. In three cases we observed that the neonaticidal mothers were from an eastern European country, employed as a caregiver, an undeclared work, which probably they have lost if they had a baby. The precarious work situation, economical difficulties and all the problems related to the emigration in a foreign country and the social exclusion, are some of that the reason than can explain why immigrant women have display a neonaticide risk factor 10 times higher than Italian women. Reproductive disinvestment, in this case, does not depend on social or cultural differences (e.g. infanticide for sex selection in China. Mann, 2011), but it is the results of precariousness and loneliness of migrant women in our country.

A consistent number of cases, as it seen in figure 4, happened in regions of northern and central Italy. Probably, according to a socio-biological point of view, in southern Italy families are larger, and this will act as a protective factor: young mothers are supported and assisted by mothers and grandmothers, so critical situations, related to reproduction are fewer than in other parts of Italy.

The data provided by the Italian Health Department demonstrate that women who most resort to abortion are aged between 20 and 24 years, and in 2006 the foreign women

who have resorted to abortion were more than 50 thousand. Camperio Ciani and Chiarucci (2010) suggest that abortion, in our species, coincides with the predictions of the reproductive divestment exactly like the neonaticide does. Our data have shown that the distribution of abortions has a convex distribution, per class of women who have offspring, while the birth rate is concave, i.e. the majority of abortions occur among young women and young girls, that in the future will reproduce again, and older women for whom pregnancy could cause serious complications and problems with regards to the unborn child (therapeutic abortions). The correspondence between abortions and neonaticides is based, for example, in the 2002 Istat data, collected in the graph in Figure 1, which shows how effectively the distributions of births and abortions going in a opposite direction. The distribution of abortions by age of mother in Figure 2 is similar to the distribution of neonaticide by age of the mothers in our sample (Figure 1), of course excluding therapeutic abortions on elder women. Sycora (2000) shows in his analysis on infanticide in Slovakia, a quick decline of these phenomena, in the years following the promulgation of the law on the interruption of pregnancy in the country. We can hypothesize that the postnatal murder (implemented mainly through abandonment and non-violent suffocation) is used as last resort, instead abortion, where the access to health services is lacking. Neonaticidal women for reproductive divestment, may not have been able to choose whether to abort or carry the pregnancy to term, and left alone, without support of any kind and even less, information, have resorted to this extreme solution. The results shown in Figure 5 bear out the theory of premeditation and exclude the raptus violence that, instead, characterizes many of infanticide and filicide made by mothers in the grip of severe psychosis. Most of the neonaticide in our sample in fact, have been made in a non-violent way or the little newborn were just abandoned. Abandonment is, according to this interpretation, a form

of modern "Wheel of the Innocents" (Hrdy, 1999; Camperio Ciani, Fontanesi, 2012), where mothers have abandoned their children, for a long time, as they could not take care of babies. Hrdy, (1999) documents that the Ospedale degli Innocenti in Florence, hosted thousand of children, and over 15,000 orphans between 1755 and 1773, abandoned the in "wheel", two thirds have died before one year, and less than 10 children reached the age of release at 8 years old. Leaving a child in the first moment after birth is the equivalent to kill him, but the neonaticide for abandonment is often preferred, because it offered an illusion. The mother forced to this extreme act, remained the hope that her child would have survived, and went to meet a better future. These aspects, like the justifications, the choice, the non violent modality, show that both the abandonment and neonaticide are rational actions with a specific motive and a strategy, even though the women are desperate and miserable. That's why no one of the mothers in our sample committed an act like suicide, because they express their willingness to live and have access to maternity in better condition in the future. Even postpartum depression may explain the neonaticide, which, unlike the other infanticides on older children, occurs before the depression is manifested (Spinelli, 2004). The neonaticide, according to the interpretation of evolutionary psychology is far from the infanticide (Camperio Ciani and Fontanesi, 2012). Frequently, in the forensic context, the diagnosis are being made after the criminal acts, and no one of the murder family and friend suspected anything. We have observed that many psychiatrists and psychologists, fall into a post-hoc methodological error: as we have shown in this work, does not mean that because a mother killed her child then is "sick or insane." This error of circular logic, is a common tautology, often erroneously applied in penal procedure to establish if the woman will is intact. The neonaticide is instead a part, obscure but apparently inevitable, of a reproductive strategy, also present in our species, here named

“comprehensive reproductive instinct”. Rather than punish this strategy, it should be important to address its prevention. It’s necessary to promote the rights of women, starting from protect their right to voluntary interrupt pregnancy, and be informed about the consequence of this act. Social and Health service should provide clear and accessible information to the disallowance of the child at birth.

### ***Limitations***

It should be noted that our cases databases is limited, compared to other studies in criminology, due to two fundamental reasons. First, as it happened in the previous study, is the absence, in our Country, of digital specialized archives, like Us Viclas or Canadian Vicap, which record all the violent aggressions and their characteristics. In the second place, we had to deal with the *dark number* of abandoned babies dumped in landfills or in outdoor garbage bins. For every abandoned newborn found dead, or saved, we can assume that there is a large number of which police don’t know nothing, and bodies were never been found, and never will.

### ***Conclusion***

This study shows that neonaticide and abortion share similar peculiarity, especially for what concern the young age of the women. The profile of these women who are at risk to incur in neonaticide or abortion are 1) at their first pregnancy 2) usually very young 3) showing a great residual reproductive potential and 4) immigrate from another country.

These results have important implications in the therapeutic assessment, as the identification of risk factors, to offer and promote adequate socio-psychological support to at risk future mothers. It is fundamental that Social and Health Service take charge to promote all the services for young women, alone, poor and immigrants, to prevent the recurrence of such crimes, although ancient, which degrade women and threaten children.

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## **CHAPTER 4 Evaluation of tympanic and rectal temperature**

### **measurements to estimate the time of death in accidents in cold water**

#### *Abstract*

The reliable measurement of core deep body temperature is fundamental to estimate the time of death (TOD). The golden standard is measuring through rectal or oesophagus probe. Recently infrared tympanic thermometers (ITT), have substituted in some cases the golden standard. We assisted as consultants a case of suspect infanticide by drowning, where the victim core temperature was collected with ITT and was used to calculate the TOD. The ITT estimated time of death was in contrast with the predictions from other biological evidences. To compare the ITT and the rectal probe temperature measurements, we tested laboratory rats, in three different conditions: alive, immersed alive, and dead immersed. The measurements did not correspond. When alive in the water the rectal temperature started slowly to decrease, while the ITT measurements rapidly dropped under 25C°, and in the dead condition rectal measurements continued to decline steadily, while ITT measurements fluctuated above water temperature. We failed to find univocal ITT measurements with time, as expected from a reliable method to estimate the TOD. We further tested the accuracy of ITT on a human volunteer exposing its right ear to 3 minutes running water at 18°C and subsequently dried. The ITT measures immediately fell under 19C°, while the whole body temperature, remained unchanged at 36.5C°. ITT measurements recovered the subject correct body temperature after 33 minutes from water exposure. These results suggest to refrain the use of ITT in forensic cases to assess the TOD, especially in cases of drowning in cold water.

## ***Introduction***

The correct estimation of the time of death is a powerful tool to direct investigations in both accidents and crimes and is frequently essential to verify alibis, limit the range of suspects, and locate witnesses. There are different methods to assess the time of death (TOD), which are generally divided into two main groups (Kaliszan, Hauser, & Kernbach-Wighton, 2009). The first consists of methods based on the evaluation of the *post-mortem* processes occurring in corpses, such as the observation of vitreous fluid biochemistry (Chen, Cai, & Wen, 2009; Sachdeva, Rani, Singh, & Murari, 2011), electric impedance spectroscopy of the contraction of human skeletal muscles, study of the processes occurring over and around the corpse, and the developmental stage of decomposers, such as insects, born since the time of death (Byrd & Castner, 2009; Davies & Harvey, 2012; Goff, 2010). The second group includes a variety of methods and techniques based on the analysis of the body's cooling process after death (Al-Alousi, Anderson, Worster, & Land, 2001; Green & Wright, 1985; Henssge & Brinkmann, 1984; Henssge, Brinkmann, & Puschel, 1984; Hiraiwa, Ohno, Kuroda, Sebetan, & Oshida, 1980; Shapiro, 1965). Rectal temperature (as a proxy of deep body temperature), which determines the degree of body cooling, is the most useful parameter in practical forensic examinations.

Although many methods have been used for the estimation of *post-mortem* intervals using rectal temperature (Fiddes & Patten, 1958; Henssge, 1981, 1988; Henssge & Brinkmann, 1984; Henssge & Madea, 1988, 2004; Honjyo, Yonemitsu, & Tsunenari, 2005; Knight, 1988a; Morgan, Nokes, Williams, & Knight, 1988; Saito G, 1953;



Tamaki K. & 1988), Henssge's nomogram (Henssge, 1981, 1988, 1992) has shown higher correlation coefficient values compared with other methods.

In forensic practice, methods based on rectal temperature are most frequently used to appraise the *post-mortem* interval because they are easy to assess and accurate within the 24-hour interval after death. Currently, this method represents the so-called *golden standard* of *post-mortem* temperature measurements (Bisegna, Henssge, Althaus, & Giusti, 2008; Crawford, Hicks, & Thompson, 2006; Honjyo et al., 2005; Muth et al., 2010). Recently, however, various researchers have suggested that the rectal temperature is correlated with the ear temperature and argued that the external auditory canal assessment of temperature could be a good indicator of the time of death (Eric Baccino, Cattaneo, Jouineau, Poudoulec, & Martrille, 2007; E. Baccino et al., 1996; Cattaneo et al., 2009; Ruty, 2005; Swift & Ruty, 2003). The ear temperature reflects the hypothalamic temperature due to the anatomical proximity of the internal ear and is believed to be reliable and sufficiently deep in the human body (Eric Baccino et al., 2007; Cattaneo et al., 2009; Ruty, 2005). Infrared thermometers have since won widespread acceptance in primary care settings, despite some debate over their accuracy (Brennan, Falk, Rothrock, & Kerr, 1995; Jaffe, 1995; Manian & Griesenauer, 1998; Rotello, Crawford, & Terndrup, 1996; Terndrup, 1992; Terndrup, Crofton, Mortelliti, Kelley, & Rajk, 1997; Terndrup & Rajk, 1992; Yaron, Lowenstein, & Koziol-McLain, 1995). These thermometers work by detecting infrared emissions from the tympanic membrane and nearby tissues. Implicit in their design is the hypothesis that the tympanic membrane temperature accurately reflects the core body temperature (Terndrup et al., 1997).

The authors assisted as consultants in a case of suspect infanticide in Italy in which the emergency service found a two-year-old female victim who was possibly drowned in an

18°C river. She had a core temperature of 24.9°C, as registered with the ITT (infrared tympanic thermometer) Genius 3000 (Sherwood Medical, Sulzbach, Germany). The mother was charged with drowning the infant in the river after a day spent walking and shopping together downtown. The event occurred with no witnesses.

The medical examiner, using the Henssge nomogram (appendix 1) (Henssge, 1981, 1988, 1992) considered the 24.9°C temperature to be accurate, and given the 12 kg weight of the victim, determined the TOD to be approximately 2 hours before the corpse was retrieved. The girl was found by the rescuers floating at 00:05 approximately 1 km away from the point where the mother had supposedly thrown the victim into the water. This TOD reconstruction corresponded approximately to the time that the mother was last seen with the victim by various CCTVs downtown at 22:10.

The mother was charged with infanticide against all other biological and thanatological data that were collected at the moment of the recovery (blood gas analysis, myocardial electrical activity and the absence of *fungus schiumosus*), which indicated a much more recent death or even just a coma, leaving a large amount of uncertainty with regard to the actual time of death. These data suggested that an involuntary accident was more likely than deliberate infanticide. The crucial point in this case was the assessment of how reliable ITT temperature measurements were. If the Henssge nomogram was based on an unreliable temperature measurement, the other evidence could potentially prevail, suggesting that the victim fell into the water at a later time. A later TOD would exclude the mother from being suspected of infanticide because she was constantly cooperating with the rescue team immediately after the alleged disappearance of the daughter from 22:10 onward.

A criminal psychological profile based on a match with 110 cases of maternal infanticide in Italy further indicated the exclusion of infanticide. The mother, who was

recently separated from her partner and the father of the victim, was also the mother of another 10-year-old child from a previous relationship, and the reconstruction showed no motive or background reason for her to commit infanticide on her two-year-old daughter (Camperio Ciani & Fontanesi, 2012).

Notably, Henssge (Albrecht et al., 1990; Henssge, 1981, 1988, 1992; Henssge & Madea, 2004, 2007) originally indicated that the correct application of his nomogram to estimate TOD had some contextual limitations. He suggested, for example, that his method was not adequate and reliable for the assessment of a very short *post-mortem* period (such as in this case, in which the 2-hour period can be considered to be short) and might not be reliable for a corpse that had been completely immersed in water (Albrecht et al., 1990; Althaus & Henssge, 1999; Henssge, 1992; Henssge & Madea, 1988). In common practice, however, these indications are not frequently respected, such as in the present case (E. Baccino et al., 1996). Recently, an investigation of the correlation between oral temperature and ear temperature recorded with a tympanic infrared thermometer suggested a marginal effect between the two measurements (Muth et al., 2010). We based on these consideration the defensive investigation line, conducting a series of experiments on three laboratory rats and a human volunteer to assess the correlation between tympanic temperature and the golden standard, deep rectal temperature, to verify whether the tympanic temperature is a reliable substitute for deep rectal temperature in the assessment of TOD in forensic cases, in order to demonstrate the medical examiner malpractice, and invalidate the TOD evidence

### ***Aim***

We aimed to provide a reliable correlation between the golden standard and infrared tympanic temperature to be eventually used in this and future cases of TOD measurements in accidents occurring in cold water.

### ***Methods***

To test the validity of the tympanic measurements, we performed three experiments under different conditions.

#### **First experiment:**

*Subject:* One aged laboratory rat that was approximately 450 g with a surface body volume ratio of  $0.146 \text{ m}^{-1}$ . The rat was sampled at 30-second intervals: first while alive and dry for 7.5 minutes and subsequently after death by cervical dislocation and submersion in running  $18^{\circ}\text{C}$  water until its rectal temperature reached  $24^{\circ}\text{C}$ , which occurred after 45 minutes, when the experiment was ended. Before the experiments, the rat ears were physically inspected for the absence of ear wax or obstructions, and both the rectal probe and the tympanic thermometer were confirmed to be consistently recording the temperature of the subject.

*Materials:* To sample the tympanic temperature, we used the ITT Genius 2 (Sherwood Medical, Sulzbach, Germany), which has been replacing the older Genius 3000A in Italian hospitals and emergency equipment. To assess the rectal temperature, we used a rectal probe connected to a Propaq monitor (Welch Allyn, Skaneateles Falls, NY, USA). The experiment was conducted in the Biology Laboratory of the University of Padova using a transparent Plexiglas container with 20 litres of water kept at a constant

temperature of 18° (monitored with a thermostat) and agitated manually to simulate running water.

*Procedure:* The rectal temperature in °C was constantly monitored throughout all the experiments and recorded for comparison at 30-second intervals. A rectal thermostat probe was placed and connected to a Propaq Encore monitor, the rectal probe was gently inserted into the rat with minimal gel lubrication down the rectum into the intestine for 60 mm to reach the deepest region of the body cavity. A trained researcher who practiced using this device for more than 250 repeated measurements in both humans and laboratory rats performed the tympanic temperature measurements. The tympanic temperature was recorded by insertion into the ear pavilion by always using a new disposable membrane-covered tip. The size of the auricle fit the registering tip with no problem.

We used two different conditions to analyse both the rectal and tympanic temperatures: first, dry and alive, and second, dead after cervical dislocation and immersion in running water.

#### Second experiment:

*Subjects:* A total of 2 older laboratory rats that were approximately 430 g with a surface body volume ratio) of  $0.146 \text{ m}^{-1}$  each. Both rats were sampled at 60-second intervals: first, while alive and dry for 11 minutes; second, alive and immersed in running 18°C water for 8 minutes and third, after death by cervical dislocation and submersion under running 18°C water until the rectal temperature reached 20°C, which occurred after 33 minutes. Additionally, these rats were physically inspected to ensure that both the rectal probe and ITT fit the anatomy of the rat and were consistently recording the temperature of the subjects.

*Materials:* To assess the tympanic temperature, we used two First Temp Genius 3000 A (Sherwood Medical, Sulzbach, Germany) thermometers. This model was originally employed in this forensic case and provided by the hospital that recorded the original temperature of the young female victim. The use of multiple thermometers excluded the possibility that the reading was influenced by malfunction due to water.

We also used the same rectal probe connected to a Propaq monitor (Welch Allyn, Welch Allyn, Skaneateles Falls, NY, USA) as above to assess the rectal temperature.

This experiment was also conducted in the Biology Laboratory of the University of Padova using the same transparent 20-litre Plexiglas container kept at a constant temperature of 18°C and agitated manually.

*Procedure:* The rectal temperature in °C was regularly monitored throughout the duration of this experiment and recorded for comparison at 60-second intervals. The rectal probe was placed in the two rats with minimal gel lubrication down the rectum into the intestine for 60 mm to reach the deepest region of the body cavity. The same trained researcher who assessed the temperature in the first experiment performed the tympanic measurement. The auricles of both rats were inspected for the absence of ear wax or obstructions, and fit the registering tips with no problems. In the second experiment, we used different conditions to analyse the rectal and tympanic temperatures: A) dry and alive, B) wet and alive and C) immersed and dead after cervical dislocation.

The number, treatment and sacrifice of the laboratory rats were approved and followed the ethical guidelines of the animal laboratory in the Biology Department of the University of Padova.

### Data analysis

Individual recordings for both the rectal and tympanic temperatures were plotted, and the errors between the subjects, the average slope per recording interval (Y= the temperature change from the previous recording at constant intervals of 60 seconds), standard deviation, and the minimal and maximal values of each of the three conditions were measured. A null slope with a low SD and low difference between the maximum and minimum would indicate a reliable method to measure the *alive and dry* condition. A constant and moderate slope, with a minimal SD and minimal difference between the minimum and maximum slopes, would indicate a reliable method to estimate the cooling process while alive and wet (indicating progressive hypothermia) and while dead and wet (simulating the TOD). Large shifts in the temperature curve between subsequent recordings would invalidate the method because at a single temperature, no unique timing could be assigned. A regression analysis was performed to estimate the angular coefficient values under the three different conditions to define how much the cooling curves changed as a function of time.

### Third experiment

A third experiment was conducted in the Evolutionary Forensic Laboratory of the University of Padova to measure tympanic temperature variation in a living human body under running cold water (rectal temperature was not recorded in this third experiment, and the external temperature, which was just used as a control for the stable body temperature of the subject during the experiment, was used as a substitute).

### *Subject*

The subject was an adult volunteer (sex male, age 53, weight 82 kg, body temperature 36.5°C).

### *Materials*

A digital Braun High Speed PRT1000 thermometer (Braun GmbH, Kronberg, Germany) was used to measure the control body temperature under the arm pit of the subject every 60 seconds.

The tympanic temperature was recorded using the same two A Genius 3000A thermometers used in the previous experiment. Running 18°C cold water was obtained with a thermostatic shower directed only at the right ear and the right side of the face; the left side of the face and remainder of the body remained dry, and the volunteer was dressed normally during the experiment. The absence of ear wax or obstructions was controlled by an inspection of the ear.

### *Procedure*

The tympanic and surface body temperatures were recorded for 5 minutes with readings at 60-second intervals before water exposure and were interrupted to start the ear exposure to the cold running water. The cold running water exposure was performed for a single ear showered at low pressure with 18°C running water pointed gently but directly at the right ear for 3 minutes. After 60 seconds, the ear was dried, and its temperature was measured. The showering was then resumed for another 120 seconds. After the running water exposure, the subject dried both the face and ear, and the tympanic and surface body temperatures were recorded every 60 seconds for approximately 30 minutes until the tympanic temperature returned to 35.2°C, which occurred after 33 minutes, when the experiment was ended.



The test and the risks of the procedure were explained to the human volunteer. He read and signed an informed consent to participate in the experiment. This experiment adhered to the guidelines of the Helsinki Declaration for the use of human subjects.

## ***Results***

### First Experiment

**Fig.1** Rat n.1 sample with the Genius 2 ITT. The vertical line represents the moment of death. The horizontal represents the Genius 2 limit

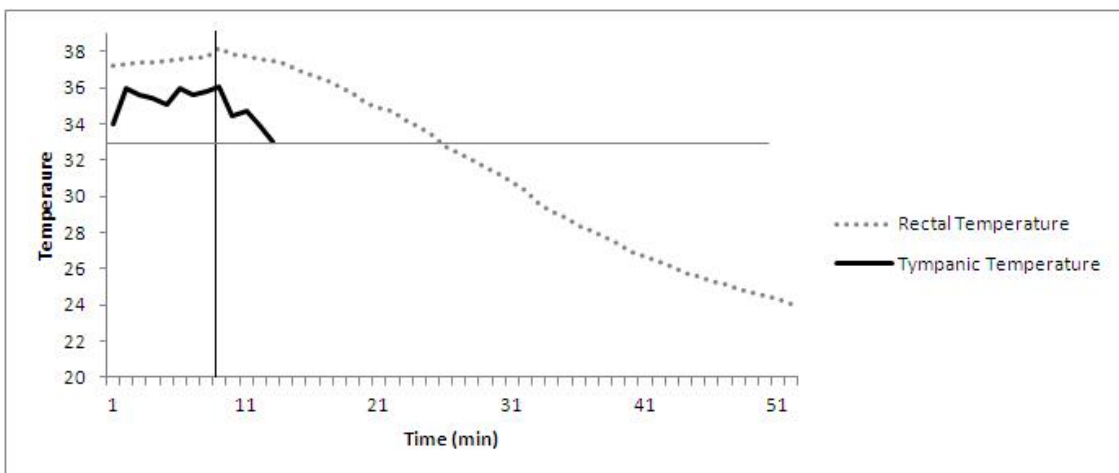
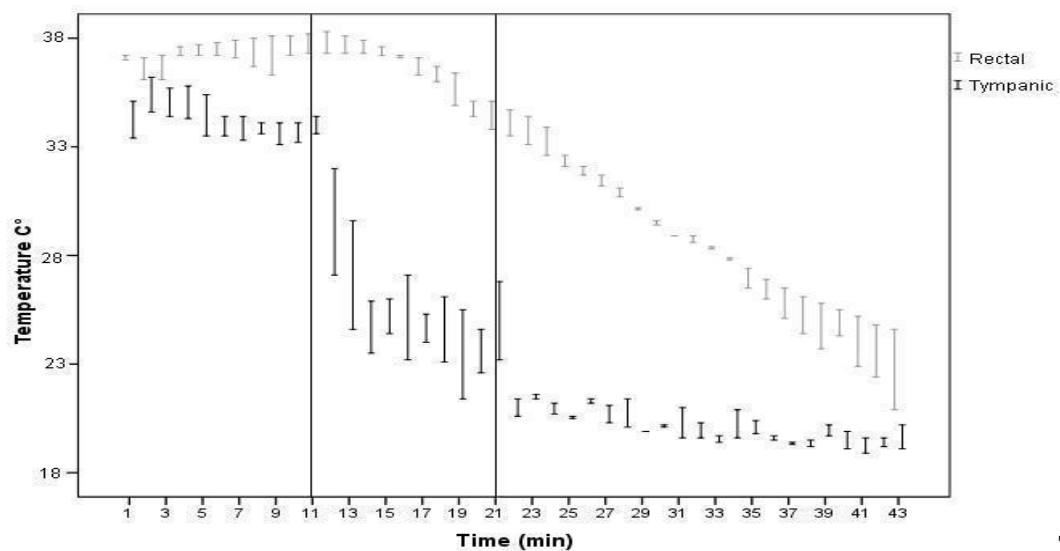


Figure 1. The temperature decrease in the first experiment, as measured by the Genius 2. In this experiment, the Genius 2 stopped registering at 33°C and never resumed recording after the first measurement after the rat was submersed in water. This observation was *a posteriori* confirmed in the user manual, which stated that this thermometer stopped reading below 33°C.

### Second Experiment

Figure 2 shows the temperature recordings in °C under three conditions (dry and alive, wet and alive and wet and dead for the second and the third rats, sampled together). The vertical lines indicate the timing of the first water immersion, death and the second re-submersion.

**Fig.2** Temperature decreases in rats n. 2 and n. 3, sampled together



The tympanic temperature was easily recorded due to the particularly large auricular pavilion of rats. The temperature recorded with the rectal probe was constant, with maximal temperature changes between the recordings of 0.2°C. The tympanic temperature was systematically 2°C – 5°C below the rectal temperature, with a maximal change between the recordings of 0.6°C.

As shown in figure 2, when the rats were submerged in the 18°C running water, the rectal temperature began to decline steadily. The tympanic temperature recordings, in contrast, dropped sharply from 34°C to 24°C within 240 seconds after the rats were submerged alive in the 18°C running water. After their deaths, the rectal temperatures continued to decline steadily without major variations, with a maximum slope of .90°C

a minimum slope of  $.05^{\circ}\text{C}$  and an average difference between the rats of  $0.135^{\circ}\text{C}$ , reaching  $21.75^{\circ}\text{C}$  in 33 minutes. The tympanic temperature did not significantly decline and presented an average variation between subsequent samples of  $M=.257^{\circ}\text{C}$  ( $sd=.276^{\circ}\text{C}$ ).

Table 1 shows the mean slope and standard error between the subsequent recordings both before and after the exposure under the three conditions.

Table 2 shows the two temperature measurements for the rats under the three conditions, with the mean difference, standard deviation, and minimum and maximum recordings for each condition.

**Table 1** Mean difference and standard error between rats 2 and 3

| <b>Differences between temperatures<br/>in the rats</b> | <b>Mean</b> | <b>Std. Error</b> |
|---|-------------|-------------------|
| Rectal Dry  | .900        | .162              |
| Tympanic Dry  | 1.07        | .152              |
| Rectal Immersed   | .722        | .112              |
| Tympanic Immersed                                       | 3.70        | 1.08              |
| Rectal Immersed-Dead                                    | .775        | .511              |
| Tympanic Immersed- Dead                                 | 2.17        | 1.21              |

**Table 2** Min, max, mean difference, and standard deviation in the temperature records under the three conditions

| <b>Conditions</b>      | <b>Min</b> | <b>Max</b> | <b>Mean differ.</b> | <b>Sd</b> |
|------------------------|------------|------------|---------------------|-----------|
| A Rectal Dry           | .00        | .45        | .135                | .149      |
| A Tympanic Dry         | .00        | .60        | .264                | .230      |
| B Rectal Immersed      | .05        | .65        | .287                | .228      |
| B Tympanic Immersed    | .1         | 4.45       | 1.343               | 1.584     |
| C Rectal Immersed-Dead | .05        | .90        | .414                | .264      |

|                           |   |      |      |      |
|---------------------------|---|------|------|------|
| C Tympanic Immersed- Dead | 0 | 1.00 | .257 | .276 |
|---------------------------|---|------|------|------|

**Table 3** Regression analysis, angular coefficients and F test for the three conditions, with time as an independent variable

| Conditions             | <i>b</i> | <i>R</i> <sup>2</sup> | <i>SE</i> | <i>F(I)</i> | <i>p</i> |
|------------------------|----------|-----------------------|-----------|-------------|----------|
| Rectal Dry             | .029     | .162                  | .026      | 1.208       | Ns       |
| Tympanic Dry           | -.148    | .567                  | .053      | 7.848       | Ns       |
| Rectal Immersed        | -.307    | .896                  | .040      | 60.584      | p<.01    |
| Tympanic Immersed      | -.946    | .628                  | .275      | 11.841      | p<.01    |
| Rectal Immersed-Dead   | -.444    | .963                  | .015      | 758.384     | p<.01    |
| Tympanic Immersed-Dead | -.078    | .503                  | .014      | 47.412      | p<.05    |

To confirm our results, we performed a regression analysis, in which *b* angular coefficients, the slopes, were an index of the temperature decreases as a function of time: the slope of the temperature decrease was the ratio between the difference of the time in minutes and the temperature between two distinct points on the regression line. Under the A condition, both *b* coefficients were not significant, as expected, because the temperature should not decrease in dry, living animals (rectal dry condition *b*=.029 *F*=1.208 *p*= ns; tympanic dry condition *b*= -.148, *F*= 7.848 *p*= ns). Under the second condition (alive and wet), both temperatures dropped significantly, but although the rectal temperature declined steadily and moderately (*b*= -.307 *F*= 60.584 *p*<.01), the tympanic temperature showed an initial sheer drop (*b*=-.946 *F*=11.841 *p*<.01) that then decelerated with an inconstant trend. Under the last condition (C, *dead and wet*), the rectal temperature continued to show a steady, moderate decline (*b*=-.444 *F*=758.384

$p < .01$ ), whereas the tympanic temperature, which was already close to the external temperature of the water, dropped slowly ( $b = -.078$   $F = 47.412$   $p > 0.5$ ), approaching the water temperature, and showed relatively large fluctuations, preventing the assignment of each temperature to an unequivocal time reading. As an example in the tympanic curve (Fig. 2), at min 29 (approximately 8 min after death), the tympanic temperature was lower than at min 39 (approximately 18 min after death).

### Third Experiment

**Fig. 3** Tympanic and body temperature  $^{\circ}\text{C}$  decreases under running water at  $18^{\circ}\text{C}$  in a human volunteer

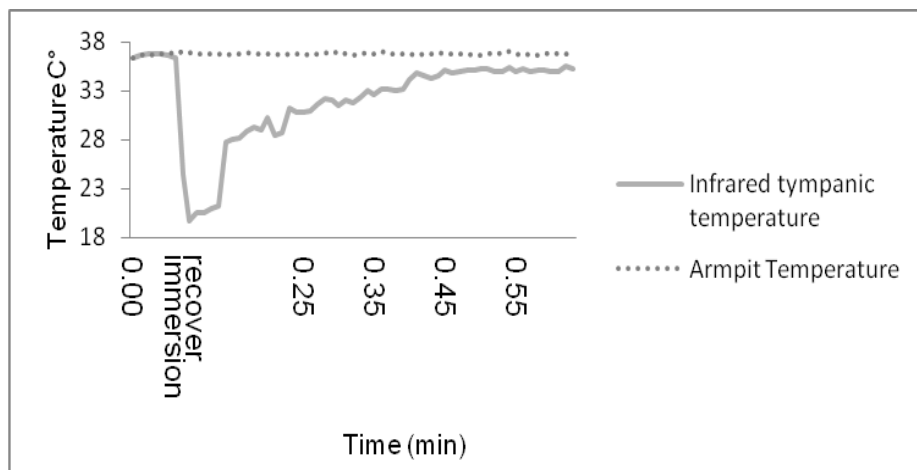


Figure 3 shows the recording of the body surface and tympanic temperatures in the human subject under the two conditions, which were before and after exposure to running water, until the temperature recovered to  $35.2^{\circ}\text{C}$ .

The tympanic recording in the dry subject before the exposure of the right ear to running water was an average of  $36.6^{\circ}\text{C}$ , and it changed  $\pm 0.15^{\circ}\text{C}$  between the 60-second recordings.

After 300 seconds of recording while dry, the right side of the subject's face, including his right ear, was exposed to a running flow of 18°C water from a shower for 180 seconds. The body temperature, which was measured under the arm, remained unchanged and was maintained at an average temperature of 36°C, with an average difference between recordings of 0.15°C before, during and after the low-pressure 18°C running water treatment of the right ear. In contrast, the tympanic temperature dropped to 24.4°C in 60 seconds and 19.7°C after another 120 seconds (Fig. 3). After the water exposure ceased, the tympanic temperature progressively improved, with an average slope of .722 (+/- sd= 1.78). The tympanic temperature recordings showed a body temperature of 35.2°C after 33 minutes.

### ***Discussion***

The present experiments showed that in all specimens exposed to cool running water, even small homoeothermic mammals of approximately 450 g, which have a relatively larger body surface to body volume ratio compared with that of the small female victim, the rectal temperature decreased slowly at a relatively constant rate. The results confirmed that rectal measurements are an adequate indicator to estimate the time of presence in cold water, either while alive or after death. The process of body cooling is different when alive because in homoeothermic individuals, it is combated by vascular contraction and increased metabolism. After death, these contrasting actions no longer participate in the process, and the cooling of the body proceeds faster (Di Maio, 1989). Estimating these forces has already been performed, which is well beyond the scope of the present study (Al-Alousi et al., 2001; Green & Wright, 1985). However, these results confirm once again that with the appropriate algorithm, deep rectal temperature is a good standard method, even for a very small body, such as laboratory rats. Thus, the rectal temperature is confirmed to be appropriate to reconstruct the time of death or the

time of body cooling (Althaus & Henssge, 1999; Henssge, 1988, 1992; Henssge & Madea, 2007).

Nonetheless, the crucial question, focusing on the present forensic case, was whether the tympanic temperature could be used instead of the rectal temperature as an adequate standard to estimate the time of death and the actual body cooling processes.

The present research suggests otherwise. As other authors suggested (Eric Baccino et al., 2007; E. Baccino et al., 1996; Cattaneo et al., 2009; Ruty, 2005; Swift & Ruty, 2003), we found that tympanic measurement could be a reliable indicator of body temperature under normal conditions when the environmental temperature is not too cold or too warm but not if the body to be measured is immersed in water. Furthermore, the relatively larger standard deviation suggests that the ITT, while able to measure temperature quickly, requires some degree of manual skill to improve the temperature measurements taken by expert personnel and in the emergency room compared with domestic measurements taken by a non-expert (Rotello et al., 1996; Terndrup et al., 1997; Terndrup & Rajk, 1992) (Terndrup & Rajk, 1992). In the present case, the researcher sampling the ITT was well trained with the Genius devices, and therefore, significant operator errors should have been excluded. This result is further supported by the observation that the measurements were constant under the dry condition, both for the rats and for the human. The fluctuations in the tympanic temperature measurements appear to not just be due to the mismanagement of the probes or to ambient factors but rather to the substantial influence of the water in the ear canal on the IR thermometry of the tympanic membrane, which alters the measurements.

Remarkably, the Genius 2, which is replacing the older Genius 3000A as the only tool to assess the body temperature of patients in most emergency settings in Italy, cannot register temperatures below 33°C. This limitation makes this instrument inadequate,

even for cases of mild hypothermia in a dry environment, and we suggest that it is highly counter-indicated for flexible and all-purpose emergency settings.

According to the results of the second experiment, the analysis of the slopes under the conditions of wet-alive and wet-dead showed that this method does not fulfil the essential prerequisites of a slow, constant and unequivocal change in body-cooling measurements, which is essential in reliably measuring the TOD. Specifically, with ITT, the slope average was extremely high under the initial *wet-alive* condition, producing a sheer drop and then rapidly decreasing (fig 2c) as the external environmental temperature was approached. Furthermore, both the standard deviation and the minimum and maximum values showed the exact opposite of a constant slow decline. Again, under the third condition of *wet-dead*, the temperature measurements did not change further because they were already near the external temperature. In comparison, the rectal temperature measurements decreased at a much slower and more steady rate. Because of the highly irregular slope of the tympanic temperature and its rapid decline to a basal temperature with no subsequent changes correlated with time in the experiments with the laboratory rats, this recording is absolutely inadequate to derive an estimate of the time of death or a reliable time function.

The experiment with the human subject further showed that such measurements are not due to some artefact associated with rat anatomy, wet ears, extremely reduced body size or short distance between the hypothalamus and ear. The experiment with the human volunteer exposed to running water at 18°C showed that the tympanic temperature dropped to 24°C in 60 seconds and 19°C after three minutes of ear exposure to cold running water. This temperature was just 1°C above that of the running cold water, showing that for any further immersion in water, the ear temperature could only marginally decrease further, one single degree Celsius. This observation suggests that



this method of temperature measurement is not informative to estimate the duration in water in either alive or dead human subjects. The effect of ear cooling by running water, such as those produced in the human experiment, shows that even for a healthy adult homoeothermic living human, several minutes (33) are required to recover normal body temperature measurements.

Muth and colleagues (Muth et al., 2010) found that in healthy human volunteers, the tympanic temperature responded more to the water temperature than oral temperature, which is in agreement with the present findings, and they suggested avoiding the use of tympanic measurements in drowning and water accidents to estimate the time in the water or the possible timing of death. Muth and colleagues (Muth et al., 2010) suggested that water in the ear canal significantly influences ITT measurements, either by cooling only the wall of the ear canal and the tympanic membrane or, more likely, by creating a cool “buffer zone” between the thermistor probe and the tympanic membrane. They observed increasingly significant *over reading* and *under reading* of measurements in high and low ambient temperatures, respectively (Muth et al., 2010). Muth and colleagues observed that even 15 min after swimming, the tympanic temperature remained lower than the oral temperature, indicating that the water in the ear canal or the ear canal itself was not fully re-warmed (Muth et al., 2010). Our findings in the human volunteer further confirmed that ambient warming and cooling of the ear canal and tympanic membrane are independent of body temperature and that water cooling may substantially affect the ability of ITT devices to measure the actual deep body temperature.

This study suggested that the rapid decrease in ear temperature measurements and the effect of exposure to cold water within the ear after drowning make all infrared tympanic thermometers, regardless of how accurate, inadequate for the measurement of

the actual deep body temperature in cold and wet settings and even in a core setting (Muth et al., 2010).

These experimental results have relevant implications in the case reported in this paper because they suggested that the tympanic temperature measurement of 24.9°C could have been measured in the ear of the victim even after just a few minutes of immersion in a river with 18°C running water and that such a measurement did not necessarily indicate immersion for 2 hours as the coroner originally maintained. The results of our experiments were used to invalidate the reconstruction of the TOD by the coroner, and they led to a supplementary investigation. The hospital then re-analyzed the biological records of the event, leading to the conclusion that the little girl was neither dead nor hypothermic at the time of rescue. Instead, the records indicated that she was almost drowned and that her heart arrested in the emergency room 3 hours after the rescue from the river after various attempts at electric resuscitation using a semiautomatic AMBU defibrillator (which delivers stimulation only if the heart is still beating and can be defibrillated). The allegation of infanticide was withdrawn, although the mother was still charged with negligent parenting.

### ***Limitations***

Generalising the results of a study on a single subject to a larger group should be performed with caution. A larger sample would have been welcomed, especially with human subjects. However, these results show similar trajectories for temperature measurements between rats and a human, suggesting that large differences between subjects should be expected. Indeed, even if some individuals respond differently to the ITT measurements, we suggest that a single case, such as the one presented here, is enough to challenge the validity and reliability of estimating the TOD with the tympanic method.

## ***Conclusion***

In water-related accidents, such as near drowning, infrared ear thermometry is not a suitable method to measure the actual deep body temperature. Further confirming these results, the temperature readings of the ITT device appeared to provide unreliable measurements of the core temperature. This inaccuracy could lead to inappropriate medical decisions, and thus, we suggest ITT measurements should not be utilised for such cases (Muth et al., 2010). Furthermore, the use of the ITT Genius 2 is not recommended in emergency settings, especially when there is a chance of encountering accidental hypothermia because of its intrinsic incapacity to record temperatures less than 33°C.

Finally, we suggest that based on our results in the present case, emergency and rescue teams should be provided with adequate and valid tools and techniques to estimate the temperature in cases of near drowning and severe hypothermia.

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## **CHAPTER 5 Errors, Guidelines and Remarks: what happens in the practice?**

### ***Introduction***

The results of the study just described leave a lot of unanswered questions.

We know that there is an open debate regarding techniques and methods related to the use of body temperature to assess the time of death (TOD) (Knight, 1988; Smart & Kaliszan, 2012). The diagnosis of the time of death, known as thanatology (Balk, Wogrin, Thornton, & Meagher, 2007), is a multidisciplinary field of study, that goes from forensic pathology to biology, through chemistry, physics and also forensic entomology. Modern studies in thanatology had permit to identify new techniques for estimating time and causes of death, e.g. the eye temperature(Kaliszan et al., 2010), composition of visceral fat (Kuk et al., 2012) the analysis of the muscles as myotonometry (Vain, Kauppila, Humal, & Vuori, 1992) or again the analysis of the arthropod that lay eggs in the body cavities (Byrd & Castner, 2009).

The reason why this discipline has such a diffusion, is because assessing the victims time of death is a crucial point in forensic practice: it allows investigators to clarify the last hours alive of the victims (Geberth & Bagerth, 1996; Mann, Bass, & Meadows, 1990), it helps to point out the causes of death (DiMaio & DiMaio, 2001; Froede, 2003) and, moreover, it's important to substantiate suspected alibis (Canter & Youngs, 2009). The aim of these chapter is to understand what happens in our country when forensic scientist have to deal with complex cases as the one descript in the first part of the chapter. Following that goal, I have been analyzing European resuscitation guidelines,

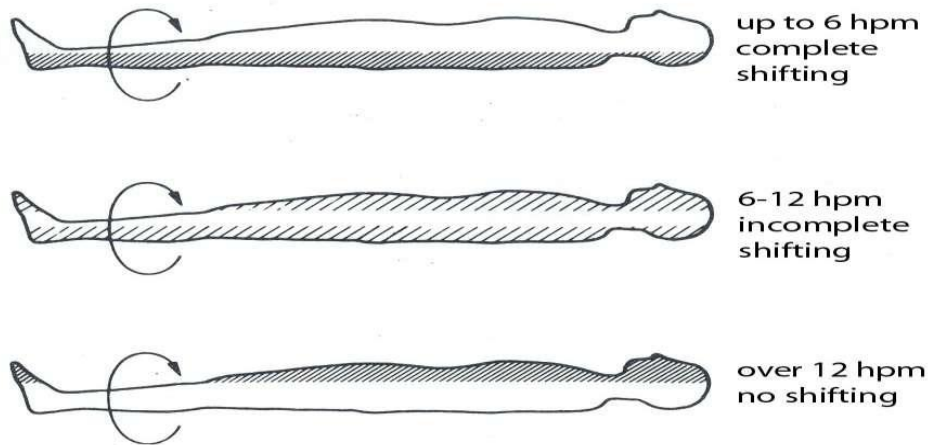
and conducted a survey on the actions in the practice of the emergency service unit and medico legal examiner in Italy.

All these aspects of the forensic medicine discipline might look marginal for a psychologist. But they are crucial in the investigative procedure, and the forensic psychologist, who uses the scientific method and deductive reasoning, need to take into account all aspects of the investigative process and understand all the evidence, to explain how criminal events developed.

### ***Aspects of thanatology***

As already said, thanatology has different subjects of studies: the bodily changes that accompany death, that allowing specialists to ascertain the death, called *thanato-diagnosis*, and the physico-chemical changes and, therefore, morphological characteristics of the corpse, with specific reference to the various factors which might influence the evolution and quantification of the post-mortem period (*thanato-chronodiagnosis*) (Zagra, Argo, Madea, & Procaccianti, 2011). According to the recent literature, the most common signs that should be take in account in the forensic thanatological process are the consecutive abiotic phenomena ( following the end of vital activities) as dehydration and drying of the skin, acidification, loss of neuromuscular excitability, temperature of body, hypostasis and cadaveric rigidity (Introna, Di Vella, & Campobasso, 2012; Vass et al., 2002). The principal cues that physician analyze to understand the time of death are those that constitute the so-called "classic triad" (DiMaio & DiMaio, 2001; Guharaj, 2003; Umani Ronchi G., 2002): the *livor mortis*, the *rigor mortis*, and the *algor mortis*. The *livor mortis*, or postmortem lividity, consists in a purplish discoloration of the skin following death. The

discoloration is a result of blood pooling in the lower parts of the body (if the body is supine), due to the force of gravity. The figure below shows the evolution of the hypostasis in the human body (Argo, 2011) :



With the term *rigor mortis*, instead, refers to the changes caused by chemical changes in the muscles after death, causing the limbs of the body to become stiff and difficult to move or manipulate. In humans, it starts after three to four hours *post mortem* (hpm), reaches maximum stiffness after 12 hours, and gradually dissipates until approximately 48 to 60 hpm (Balk et al., 2007; Tsokos & Byard, 2012).

The *algor mortis*, the decreasing of post mortem temperature, is probably the most important abiotic sign to set the time of death. The interruption of the vital functions and the consequent loss of metabolic processes mean that the body -exposed, as usual, at a temperature environment below 37 ° C - will gradually reach the ambient temperature leaking progressively its heat by conduction, convection, radiation and evaporation. In the clinical reality, the cooling of the human body, due to the heterogeneity of the tissues and organs which it is composed, cool off following a sigmoid decreasing with slowly temperature changes (plateau) in the first hours after death and in the early hours close to the alignment of the body temperature with the ambient temperature (Dolinak, Matshes, & Lew, 2005). As already said in the previous

study, the *algor mortis* is affected by different factors as adipose tissue, mass and body surface ratio, possible hypothermia or hyperthermia, ambient temperature and humidity, clothes, and aspects of the ambient (as body found in water, mountain or under the sun in the open air) (Dolinak et al., 2005; Geberth & Bagerth, 1996). Due to all these aspect, it is fundamental to use a valuable techniques, as for example, the Henssge Nomogram and its correction factors (Henssge, 1988; Henssge, Knight, Krompecher, & Henssge, 1995; Henssge & Madea, 2004, 2007) , to settle correctly and in short times, the time of death, as in the first part of the chapter.

### ***The practice in thanatology***

Research in thanatology is crucial to improve both the existing and the new methods to understand the causes of death and to ascertain the time of death, but in the practice the numerous variables characterizing the body, the ambient and the people involved can lead, even the most expert physician, to malpractice. The pronouncement of death (legal death), in our country, consists in all the medico-legal procedures that follow and individual death (in hospital or in other context): perform the diagnosis of death, produce the declaration of causes of death, begin the autopsy, eventually authorize the removal of organs and authorize the burial (Fiori, 2009). For what concerns the first point, the diagnosis of death is not a clear and unique concept as it appears. There are three different aspects of “death” in the medico legal field: one aspect concerns the collapse of cardio-circulatory system (*clinical* death), one the collapse of the respiratory function (*real* death) and the last one the breakdown of the neurological system (*legal* death) (Comitato nazionale per la bioetica, 1991). If the death occurs within a hospital setting, a board of experts will be nominated to dispose the pronouncement of death.

But, according to the Department of Health, if the death occurs outside the hospital setting, the physician can confirm the effectiveness of death only after at least 15 hours and he has to report the causes of death after 24 hours. This process can be done by any physician, even the family doctor (for what concern the *clinical* and the *real* death, the *legal* death should be declared only after an accurate necroscopy by a physician pathologist –who, surprisingly is represented by any medical divisions director in the hospital) (D.M. Sanità 22 agosto 1994, n.582; D.M. 11 aprile 2008). If a violent death or crime (e.g. murder) is involved, or the family doctor suspect a violent death (e.g. poisoning, non-accidental drowning) the victim body should be left to the Juridical Authority to eventually perform an autopsy that clarify the causes of death (Jourden, 2004).

Currently, in many areas of our country, the measurement concerned the pronunciation of death are executed by the Emergency Service “118” (Jourden, 2004). Due to the lack of communication between the Emergency Service purpose (first aid) with the medical diagnosis of death and the medico-forensic analysis of the crime scene. For this reason, the correct estimation of the time of death could be compromised by the lack of preparation and competence of the emergency service teams in the forensic field. It should be noted that,, in the practice, before becoming a *crime scene*, an environment where a body is found, is a place where someone need to be rescued and treated by medical assistance.

Here, I am taking into account two different situations, where the correct measurement of the body temperature is fundamental to estimate the time of death

***Rescue and resuscitation in wild condition: European resuscitation council  
guidelines for hypothermia and drowning***

Biological homeostasis maintain body core temperature constantly around 37-38 C°, accidentally hypothermia occurs when environment condition are collapsing the core temperature below 35 C° (Mechem & Danzl, 2011). The most common classification defines mild hypothermia around 35-32 C°, moderate hypothermia 32-28 C° and severe hypothermia when the core temperature drops under 28 C°. The severity of symptoms and signs of hypothermia vary depending on the three degrees: in mild hypothermia patients may show e.g. shivering, hypertension, tachycardia, and vasoconstriction and mental confusion (McCullough & Arora, 2004) moderate hypothermia is characterized by violent shivering, muscle mis-coordination, skin starts to become pale and lips, fingers and toe starting to take on a purple color (Headdon, Wilson, & Dalton, 2009; Helm, Hauke, & Lampl, 2001; Schneider, 1992); in severe hypothermia as body temperature decreases further physiological systems fail functioning and respiratory and heart rate decrease (Brown, Brugger, Boyd, & Paal, 2012; Cimpoesu, Ciumanghel, & Popa, 2012; Headdon et al., 2009) . In light of the significant differences in the severity of symptoms and signs, every stage of hypothermia needs a different type of re-warming, which could be passive (for mild hypothermia), active external (moderate) or active internal (severe) (Brát, Skorpil, Bárta, Suk, & Schichel, 2004; Farstad et al., 2001; Mallet, 2002). Rescue teams have to take into account that in some cases, hypothermia may produce a protective effect on the brain after cardiac arrest (Bolgiano, Sykes, Barish, Zickler, & Eastridge, 1992; Nolan et al., 2003): cold alone may produce a very slow, small-volume, irregular pulse and and not recordable blood pressure. Hypothermia protects the brain and vital organs, and associated arrhythmias are potentially reversible. In fact, at 18 °C the brain can tolerate periods of circulatory arrest

for 10 times longer than at 37 °C (Polderman, 2004; Tisherman, Rodriguez, & Safar, 1999). Different types of care and treatment are therefore highly dependent on the core temperature recorded on the victim. According to these differences, a low-reading thermometer is needed to measure the core temperature and confirm the diagnosis. European guidelines suggests to use an oesophageal thermometer (a probe), because this temperature well correlates with the heart one, or a rectal and bladder temperature. Epitympanic measurement (using a thermistor technique) are not recommended, in fact, the tympanic temperature can be lower than the oesophageal one if the ambient temperature is very cold, the probe could be not well insulated, the external auditory canal could be blocked and, during cardiac arrest, there is no flow in the carotid artery (so it's really difficult to take the tympanic temperature) (Brugger & Durrer, 2003; Durrer, 1993; Lefrant et al., 2003; Rogers et al., 2007). For these reasons is highly discouraged the use of infrared tympanic thermometers, which do not seal the ear canal. Finally, in the hospital setting, the method of temperature measurement should be the same throughout the resuscitation and rewarming.

Drowning is a major cause of death in Europe, and affects mainly children and young people (Peden & McGee, 2003; Szpilman, Bierens, Handley, & Orłowski, 2012). This accident deriving pathology is defined as a process resulting in primary respiratory impairment from submersion/immersion in a liquid medium, where a liquid/air interface is present at the entrance of the victim' s airway, preventing the victim from breathing air. When attempt to resuscitate a victim of drowning, there are several aspects to take into account, which can lead to different outcomes, e.g. injures due to a fall in the water, whether the water was salt or fresh (Szpilman et al., 2012; Vanin & Zancaner, 2011). The standard basic procedure, in fact, as recovery from the water, rescue breathing and chest compression, sometimes is not sufficient to resuscitate a victim, often is necessary

to defibrillate, or more often, the victim drowned in cold water, and may develop primary or secondary hypothermia (Kawati, Covaciu, & Rubertsson, 2009; Nuckton et al., 2002). In addition to the crucial consequences of a correct detection of the core temperature in hypothermia, the European guidelines suggest to limit the use of the AED defibrillator to 3 attempts, and to heat the victim's body until it reaches a temperature of at least 30° C degrees (Handley et al., 2005).

It appears therefore clear, that a correct detection of the deep temperature is absolutely necessary, both in the case in which the aim is to resuscitate the victim or in case the same temperature should be use for ascertain the time of death. In the previous study, has already been demonstrated that the infrared tympanic temperature is not a reliable method to detected the core temperature in case of drowning in cold water. Notwithstanding, the European guidelines do not specify how to record the core temperature on a victim of drowning.

***A focus on Italy:***

In the lights of these considerations, it remains an open question: how measurements are conducted on the victims of these particular incidents by the emergency service? And what is the relationship between the measurements made by the emergency services and the ones collected by coroner? To try to answer these questions, a review was conducted in our country, in order to shed light on the case described in the previous study. At the end, 3 controversial famous cases of homicide were described, in order to show how crucial is the correct estimation of time of death.



## Methods

To address this question, a short survey has been conducted on two different subjects. The first object of interest is the SUEM- *Servizio Sanitario di Urgenza ed Emergenza*, the Italian Emergency Service, which operated through ambulances and helicopter to rescue and saving people in Italy. Through the analysis of the local SUEM websites, and the website of the Italian Ministry of Health we tried to reach information about their equipments, guidelines and instruments to save people in wildy conditions, e.g. on mountains, in cases of avalanches where the risk of hypothermia is high.

In order to understand what happens in the practice in our country, MDs of Legal Medicine Departments of the Universities of Modena and Reggio Emilia, Bologna, Bari, Firenze, Milano, Sassari, Macerata and Roma have been involved in the short interview, by email and phone, and in order to protect their identity, their responses, rather similar, have been grouped and reported anonymously.

The information about the cases presented, were taken from the analysis of specialized books and from the archives of major newspapers that have followed the penal processes reported.

## Limitations

For what concerns the survey on the SUEM, the first thing which need to be underling is the bureaucracy, and the chaotic division of responsibilities for the control and supervision of this service. The websites are managed at a local level, they report different information, often incomplete or missing, concerning the procedures and equipment in their services. Therefore, were also consulted amateur websites where team members exchanged information on the first aid procedures and instruments that they used in their work.

Several representatives of the Medico-legal Departments in Italian University were contacted by e-mail to answer the questions, but a very small number of them answers back. We tried to reach them by phone, and the results is that only 9 Departments participated to the survey. Moreover, not all of them were able to complete the survey, because in their departments were not carried out the procedures subject of the survey.

#### SUEM - Servizio Sanitario di Urgenza ed Emergenza

Emergency Service, in Italy, consist primarily of a combination of volunteer organizations providing ambulance service, supplemented by physicians and nurses who perform all advances life support (ALS) procedures. In our country, emergency medical service are under Public Health Authorities control in each Italian Region, but the ambulance subsystem is provided by a variety of different sources, supervised by the Sanitary Regional Authorities (D.P.R. 27/03/1992). Several organizations and volunteer associations, as Italian Red Cross, ANPAS, religious associations, Misericordia, Civil Protection, Firefighters, provides ambulance and staffing, with different training. Also helicopter air-sea rescue emergency service (*elisoccorso*) is provided by private corporations (D.P.R. 27/03/1992), and regulated by the European Joint Aviaro Authorities (JAA) (D.M. 38/T 30/3/1998). The Ministry of Health established the National System Guidelines (D.M. 30/5/2004), which provided general guidelines on the procedure and the equipment, on the line of those provided by the European Resuscitation Council but, due to the complicated picture of associations and organizations, the general policy seems to be the to follow guidelines provided at a more local level.

For example, in 2005 were issued regional guidelines for what concerns helicopter emergency service (C17, normativa 54), which ratify the standard of the service, the characteristics and the competences of the sanitary staffs. It also specifies how the equipment on the helicopters should be composed and aren't mentioned any recording temperature device. Nevertheless, Treviso SUEM adopts the Consensus Guidelines on Mountain Emergency Medicine 2003 (Durrer, Brugger, & Syme, 2003), which suggests to equip rescue teams on helicopters, which operated in areas at high risk of avalanches, with a device who recorded the deep temperature, preferably an oesophageal one. The same directions are followed by the White Cross in Alto Adige and Trentino, of the mountain rescue service of Emilia Romagna, Lombardia and Piemonte, but often the oesophageal thermistor is replaced with an epitympanic device. That is clearly subject to all the drawbacks already submitted.

The situation is different, concerning the equipment on the ambulance, which are more likely involved in the rescue of drowning victim compared to the mountain emergency helicopters. According to the D.M. 553/87, the thermometer (any kind of temperature recording device) does not appear in the required equipment included on ambulances. Nonetheless, rescue team members have a special backpack, for bls (basic life support) or als (advanced life support), and it is at their own discretion choose whether to insert an instrument for temperature recording. Generally the instrument adopted, however, is a fast reading thermometer, usually a tympanic thermometer.

Considering these information, the treatment of hypothermia, albeit the mild one, is dependent on the skills and competence of the rescuer, but this pathology will not be adequately detected until the arrival of the victim at the emergency room. In any case, it is not possible to use the temperature measured on the place by rescuers of SUEM, even if the victim is found dead or dies along the way to the hospital.

### Medico Legal Examiners

Considering the procedure followed by the medical examiner, reported in the previous study, the estimating of the time of death in such wild conditions seems to be demanding and free of shortcomings. Generally, the autopsy is disposed at least 24 after the death, and has three different and main aims: to clarify for the victim's family the causes of death, to prevent disease, and in case of a suspected crime, to ascertain the causes and eventually the time of death (requested by the prosecutor). If there is already a suspected charged with the crime, his lawyers can nominate an expert who can assist the autopsy with the prosecutor's and, eventually the court's, experts physicians (art.360 Italian Penal Code).

In the present investigation, members of the departments of legal medicine has been asked questions about: 1) what kind of methodologies and technique they normally use to assess the time of death 2) what thanatological data they take into account to estimate the TOD 3) what kind of methodologies they use to estimate TOD in victims found in water and 4) if they have ever applied the Henssge nomogram, and in case of a positive answer, what kind of information they use to complete it and where they reached those information. The out coming answers depict an interesting panel. All the respondent to the first question, usually prefer to estimate the time of death taking into account the information concerned the "classic triad", *livor*, *rigor*, and *algor mortis*, which means hypostasis, rigidity of the body, and deep body temperature (usually from the liver or the tympanum). According to the respondents to the second questions, in special cases, the gastric and intestinal contents are very important to settle the time of death, in relation to how much food has been digested. Who generally apply the Henssge

nomogram, suggests to consider also the ambient temperature, the clothes wearing by the victims and his weight.

For what concern question number 3, about the TOD estimation in victim found in water, the respondents discouraged the use of Henssge nomogram, focus their attention on the potassium dose in the *umor vitreo* and, especially, on the cadaveric rigidity. The participants to the survey who usually do not use the Henssge nomogram, emphasized that especially to assess the time of death in bodies found in water, the use of the nomogram is not recommended. This because when submerged, mass and body weight are apt to substantial changes, and the environment where the body is found may not be the same where the victim died: in this case, circumstantial information may lead for an external temperature variability during the period between the time of death and the collection of data. On the contrary, the experts interviewed who routinely apply the nomogram to estimate the TOD, affirm to usually record the ambient temperature, the rectal temperature and the victim weight, together with the corrective factors (number and thickness of clothes, characteristics of the ambient). All the participants, however, did not use, in the TOD estimation procedure, information that were coming from the emergency service. They only used personally collect information on the scene inspections, under penalty of the accuracy of the results.

Considering these outcomes, the case reported in chapter 4, appears to be a specific case of malpractice, where the incorrect use of the information and the erroneous application of Henssge nomogram, lead the medical examiner to wrong conclusions. In despite the suggestions of the interviewed experts, professionals mistakes of this sort seems to be frequent in the forensic practice. In the lasts years, have risen to record several murder cases, where the time of death was the object of the dispute between

prosecution and defense, in order to confirm or to drop the charges on a possible suspect, without, in some cases, ever get to determine the actual time of death.

In a very well-known Italian infanticide case, a mother was charged to have kill her 3 years old son, and found guilty. However, even after the verdict, discrepancies continue to exist, regarding the time and the cause of death. The victim were declared dead in the Emergency Room, but the first autopsy, revealed that the injuries on the victim's body, should have led him to death in a very short period of time. Further analysis on a number of biological evidence found on the crime scene, and on the victim, led experts to repetitively move forward and backward the time of death, without ever reaching an agreement on the TOD (Davolio, 2003; Mastronardi, 2007).

In another emblematic and more recent case, a woman was founded stabbed, and her husband was charged with murder and convicted. The woman body stabbed to death, was found dead in a park, where she was spending some time, two days before the retrieval, with her husband. The testimonies confused, the lack of an alibi, and the presence of a mistress in the life of the husband, led to the guilty verdict for the man. However, on the scene, neither the SUEM or the medical examiner, registered the deep temperature on the woman body, and during the autopsy the physician weren't able to estimate the TOD.

Finally, in one more controversial case, a young girl found dead in a well, in advanced decomposition, has for long time being in the press headlines. At the beginning, the little girl uncle confessed the murder, but few months later, the cousin and the aunt of the victim (respectively daughter and wife of the uncle), were charged of the murder. According to the prosecutor, the motive was the jealousy of the cousin toward the victim. Due to the advanced state of decomposition of the body, was not possible to determine the time or the precise day of death. However, according to the analysis of

the victim stomach contents, the biochemistry experts nominated by the defense was able to move forward the time of death, relieving their clients from the charge for murder. Not enough, the medical examiner who conducted the autopsy did not agree with those conclusion, and as a result the two women are still under the police custody, waiting for the final verdict.

### ***Conclusion***

According to the results, albeit preliminary, of this survey, procedural mistakes and lack of unique rules in the practice have led to controversial outcomes in legal process in Italy. Especially concerning the SUEM conduct, it should be mandatory for ambulances to carry, always, a temperature recording device (better an oesophageal one), especially if they had to rescue victims in wild conditions.

These findings underline the need of further studies in regard of the techniques to estimate the post-mortem period, and they suggests the necessity of an adequate training for the rescue teams members, in order to provide the best care, and to preserve important evidence, as can be the body temperature for the estimation of time of death.

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## GENERAL CONCLUSIONS

In this thesis I've explored the applications of evolutionary psychology in the forensic practice, outlining the role of investigative psychologist. The evolutionary forensic psychology is a modern discipline, whose objective is to analyze violent behavior, identify the causes that generate it, in order to provide concrete support to the comprehension of the motives and solving crimes. This discipline, born between psychology, biology and anthropology, makes use of the scientific method-deductive, and thanks to these peculiarities, evolutionary forensic psychology can be applied in various fields. In these three years- research I have explored some of these applications. The research outcomes have both theoretical and practical implications, and are going to lay a groundwork for a deeper analysis of violent behavior, according to an evolutionary approach, that still not widespread in our country. First, It has been described for the first time the *sexual presence*, a special kind of the larger concept of presence which is a phenomena involved in the assessment of paraphilias and violent behavior through virtual reality. This work in collaboration with the Philippe Pinel Institut in Canada, might be very important, since the application of new technological methodologies in the assessment and prevention of criminal violent behavior, is not very widespread in our Country.

Second, analyzing the phenomena of maternal infanticide in our Country, it has been found that maternal neonaticide, in our species, has an evolutionary cause, and the neonaticidal woman profile is different from infanticidal and filicide ones. These suggestions have relevant effects both in the investigation phase, which includes the definition of the motive and the individuation of the possible offender and in correctional assessment, where the reasons behind the violent act are important, both

from the point of view of the definition of punishment and from the rehabilitation one. This study also enlighten the condition of distress and disadvantage in which some young pregnant women strive . These results might have thus significant effects in the definitions of preventive measurements devoted to at-risk future mothers. Moreover, these results show how fundamental can be the role of the psychologist and his knowledge, in the criminal investigation process, where the motive underling the crime is not clear.

Then, I had the chance to applied the scientific methodology in a real case of suspected maternal infanticide, and I conducted a set of experiments using animal model, to evaluate the accuracy of the victim time of death, declared by the medical examiner. The outcomes of this research, invalidated the only evidence against the mother, and enlighten a case of malpractice. In light of these results, it has been noticed the lack of regulations in our country about the estimating of TOD, and I provide suggestions to improve medico –legal and resuscitation actions in the forensic practice.

These studies show the versatility and the practical value of evolutionary psychology in the forensic domain. This research shows how important and resourcefulness is the role of psychology in the forensic investigation, which, in our country, has a marginal importance. Investigative psychology is a burgeoning discipline in Europe, and is integrated with several theories and methodologies from medicine, social sciences, law, ergonomics and engineering.

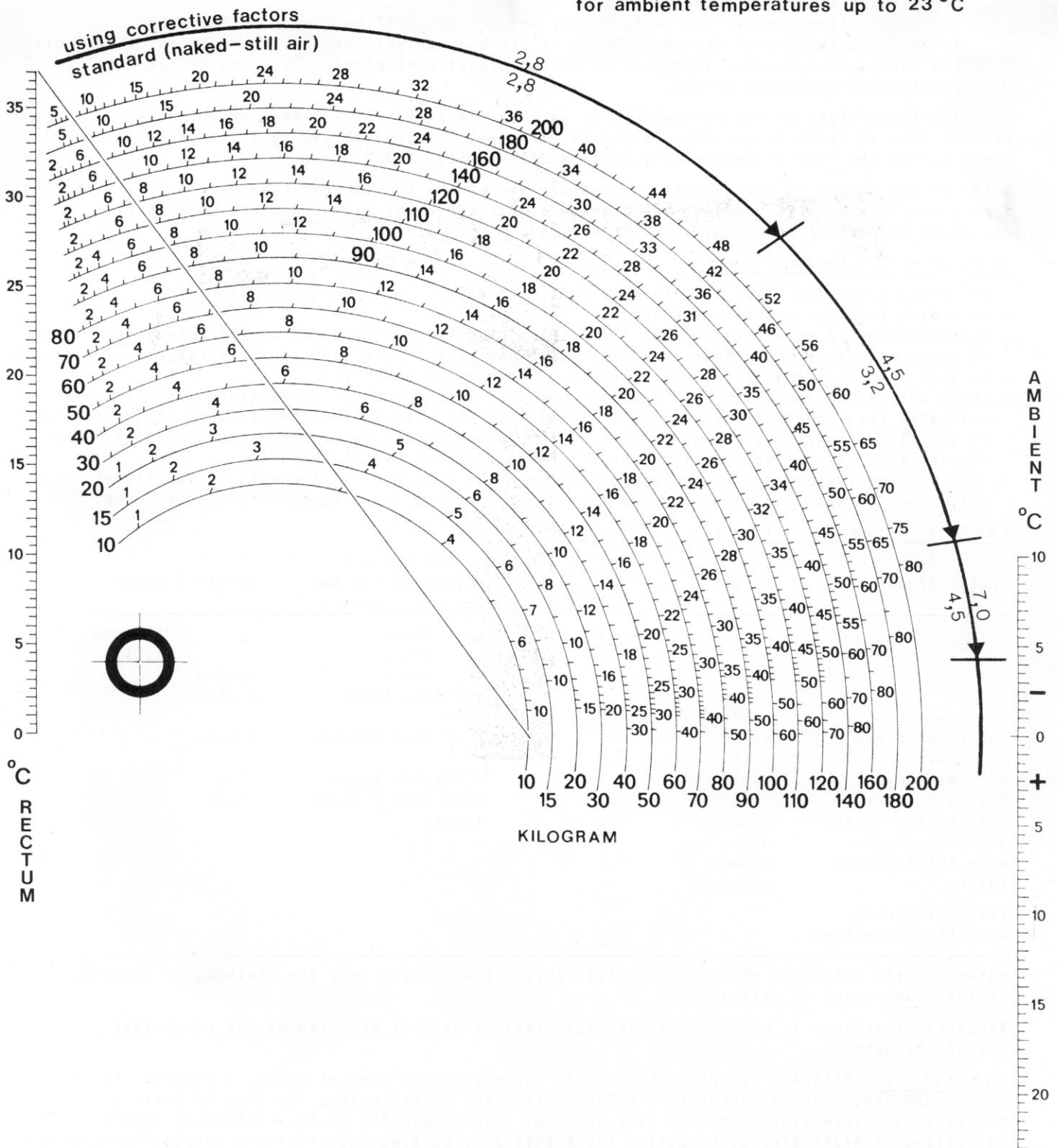
In fact, the most important outcome of this work is to demonstrate how the techniques and theories learned during three PhDs years, have important applications in the clinical, criminological and forensic practice, and how it is fundamental to carry on researches in evolutionary forensic psychology, due to its social implications.

## **Appendix**

PERMISSIBLE VARIATION OF 95% (±h)

# TEMPERATURE TIME OF DEATH RELATING NOMOGRAM

for ambient temperatures up to 23°C



The nomogram expresses the death-time (t) by:

$$\frac{T_{\text{rectum}} - T_{\text{ambient}}}{37.2 - T_{\text{ambient}}} = 1.25 \exp(B t) - .25 \exp(5 B t); B = -1.2815 (\text{kg}^{-.625}) + .0284$$

The nomogram is related to the chosen standard i.e. naked body extended lying in still air. Cooling conditions differing from the chosen standard may be proportionally adjusted by corrective factors of the real body weight, giving the corrected body weight by which the death-time is to be read off. Factors above 1.0 may correct thermal isolation conditions, and factors below 1.0 may correct conditions accelerating the heat loss of a body.



## How to read off the time of death

- I. Connect the points of the scales by a straight line according to the rectal and the ambient temperature. It crosses the diagonal of the nomogram at a special point.
- II. Draw a second straight line going through the center of the circle, below left of nomogram, and the intersection of the first line and the diagonal.  
The second line crosses the semi-circles which represent the body weights.  
At the intersection of the semi-circle of the body weight the time of death can be read off.  
The second line touches a segment of the outermost semi-circle. Here can be seen the permissible variation of 95%.

Example: temperature of the rectum 26.4°C; ambient temperature 12°C; body weight 90 kg.  
Result: time of death 16 ± 2.8 h. Statement: the death occurred within 13.2 and 18.8 (13 and 19) hours before the time of measurement (with a reliability of 95%).

Note: if the values of the ambient temperature and/or the body weight (see "corrective factors") are called into question, repeat the procedure with other values which might be possible. The range of death-time can be seen in this way.

### Requirements for the use

- no strong radiation (e.g. sun, heater, cooling system)
- no strong fever or general hypothermia
- no uncertain (+) severe changes of the cooling conditions during the period between the time of death and examination (e.g. the place of death must be the same as where the body was found)
- no high thermal conductivity of the surface beneath the body (++)
- + Known changes can be taken into account: a change of the ambient temperature can often be evaluated (e.g. contact the weather station); use the mean ambient temperature of the period in question. Changes by the operations of the investigators (e.g. take any cover off) since finding the body are negligible: take the conditions before into account!
- ++ Measure the temperature of the surface beneath the body too. If there is a significant difference between the temperature of the air and the surface temperature use the mean.

### Empiric corrective factors of the body weight

| dry clothing/covering    | in air            | corrective factor | wet through clothing/covering wet body surface | in air / water |
|--------------------------|-------------------|-------------------|--|----------------|
|                          |                   | .35               | naked  | flowing        |
|                          |                   | .5                | naked  | still          |
|                          |                   | .7                | naked  | moving         |
|                          |                   | .7                | 1-2 thin layers                                | moving         |
| naked                    | moving            | .75               |  |                |
| 1-2 thin layers          | moving            | .9                | 2 or more thicker                              | moving         |
| naked                    | still             | 1.0               |  |                |
| 1-2 thin layers          | still             | 1.1               | 2 thicker layers                               | still          |
| 2-3 thin layers          |                   | 1.2               | more than 2 thicker layers                     | still          |
| 1-2 thicker layers       | moving or         | 1.2               |  |                |
| 3-4 thin layers          | still             | 1.3               |  |                |
| more thin/thicker layers | without influence | 1.4               |  |                |
|                          |                   | ...               |  |                |
| thick bedspread          |                   | 1.8               |  |                |
|                          |                   | ...               |  |                |
| + clothing combined      |                   | 2.4               |  |                |

Note: for the selection of the corrective factor of any case, only the clothing or covering of the lower trunk is relevant!

Personel experience is needed, nevertheless, this is quickly achieved by the consistent use of the method.

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